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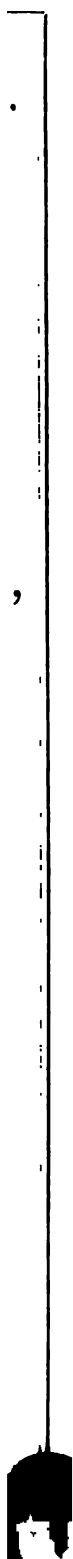
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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
BULLETIN No. 2.

REPORT UPON INVESTIGATIONS

RELATING TO THE

TREATMENT OF LUMPY-JAW,

OR

ACTINOMYCOSIS, IN CATTLE.

BY

Dr. D. E. SALMON,
CHIEF OF THE BUREAU OF ANIMAL INDUSTRY.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., February 10, 1893.

SIR: I have the honor to transmit for publication the following report upon investigations relating to the treatment of lumpy-jaw, or actinomycosis, in cattle, together with a detailed report upon the experiments conducted at Chicago by Dr. V. A. Norgaard, to whom was assigned the personal supervision of the work.

Very respectfully,

Dr. D. E. SALMON,
Chief of Bureau of Animal Industry.

Hon. J. M. RUSK,
Secretary of Agriculture.

REPORT UPON INVESTIGATIONS RELATING TO THE TREATMENT OF LUMPY-JAW, OR ACTINOMYCOSIS, IN CATTLE.

REVIEW OF THE WORK.

Since 1889 the disease of cattle known scientifically as actinomycosis, and popularly as "lumpy jaw," has attracted much attention in the United States on account of sensational publications alleging its great prevalence and dangerously contagious character. The Illinois board of live-stock commissioners appears to have been the first to accept this view and the most active in promulgating it. Since 1888 that board has seized and slaughtered a large number of animals both at the Union Stock Yards at Chicago, and at the National Stock Yards at East St. Louis. As there were included among the animals seized many in the best of condition and but slightly affected, and as these were turned over to parties for rendering purposes who allowed to the owners for a long time less than one-third of what the carcasses were worth even for that purpose, there was naturally much dissatisfaction created. It was claimed that, in addition to the unnecessary and unjust loss on affected animals which the owners were compelled to suffer, the inspection was not uniform; that many affected animals were not siezed; that those badly affected were in some cases passed by the inspectors as fit for food, while in other cases those but slightly affected and in good condition were sent to the rendering tanks. More than this, the contagiousness of the disease among animals and the danger of its transmission to man, as well as the jurisdiction of the State board of live-stock commissioners in assuming the duty of meat inspectors were seriously called in question.

The Bureau of Animal Industry was confronted with this condition of affairs when it began the inspection of meat at Chicago under the act of Congress approved March 3, 1891. The shippers of cattle at once made numerous complaints of the arbitrary, arrogant, and unjust manner in which the State board was acting, and, on the other hand, the board attempted to dictate to the Department as to what carcasses should be condemned by its inspectors and what passed as fit for food. It became necessary, therefore, that this Bureau should make an investigation as to the facts and take such action in its own work as would secure justice to the cattle owners, and at the same time pro-

fect the consumers of meat from any carcasses that were in the slightest degree dangerous to the public health.

The matter has been a difficult one to adjust because there existed, on the one hand, a board which has not hesitated to make the most sensational assertions, alarming to the consumers and damaging to the meat trade of the country, and on the other, a body of consumers exacting as to the quality of their food, sensitive to any aspersions upon it, and disposed to ask the destruction of meat though perfectly wholesome, if a breath of suspicion had been directed against it. This disposition of consumers, and the desirability of protecting the public health at any cost, no doubt accounts for the ability of the board to maintain its seizures for so long a time, though they were generally recognized as unjust, and suspected to be without legal authority.

In the spring of the year 1892, the attention of the Department was called to a remedy which appeared to have extraordinary effects in the treatment of this disease. An experiment was made on a single steer, which was badly affected, by Dr. Norgaard, an inspector of the Bureau of Animal Industry, and this steer was completely cured.

The following announcement was then made for the information of those interested in this subject:

The interest which has been shown by the stockmen of the United States in regard to the disease known as "lumpy-jaw," or that form of actinomycosis which appears as external swellings on the head, renders it desirable that a preliminary statement should be made concerning the treatment of this disease. Until recently it has been the opinion of the veterinary profession that a cure could only be obtained by a surgical operation, and that this should be performed in the early stages of the disease in order to insure success.

In March last an important contribution to our knowledge of this subject was made by M. Nocard, of the Alfort Veterinary School, in a communication to the French Central Society of Veterinary Medicine. He showed clearly that the actinomycosis of the tongue, a disease which appears to be quite common in Germany and is there known as "wooden tongue," could be quickly and permanently cured by the administration of iodide of potassium. M. Nocard calls attention to the success of M. Thomassen, of Utrecht, who recommended this treatment as long ago as 1885, and who has since treated more than eighty cases, all of which have been cured. A French veterinarian, M. Godbille, has treated a number of cases with the same remedy, all of which have been cured. M. Nocard also gives details of a case which was cured by himself.

All of the cases referred to were actinomycosis of the tongue, and no one appears to have attempted the cure of actinomycosis of the jaw until this was undertaken by Dr. Norgaard, veterinary inspector of the Bureau of Animal Industry. He selected a young steer in April last, in fair condition, which had a tumor on the jaw measuring $15\frac{1}{4}$ inches in circumference, and from which a discharge had already been established. This animal was treated with iodide of potassium, and the result was a complete cure, as stated in the reports which were recently given to the press at the time the animal was slaughtered in Chicago. If lumpy-jaw can be cured so easily and cheaply as this experiment would lead one to suppose, the treatment will prove of great value to the cattle-raisers of the country. As is well known, there is a considerable number of steers weekly coming to our markets which are condemned because they are diseased to such an extent that the general condition of the animal is affected. If these could be cheaply and readily cured by the owners, it would

prevent the loss of the carcass and solve all the troublesome questions which have been raised in regard to the condemnation of such animals.

The curability of the disease does not affect the principles which have been adopted in inspecting and condemning animals affected with it. This Department has never considered it necessary to condemn animals affected with actinomycosis on account of the contagiousness or the incurability of the disease. Such condemnations have been made when the disease was so far advanced as to affect the general condition of the animal, and all such carcasses would be condemned whether the disease from which the animal suffered was contagious or not, or whether it was curable or incurable.

The treatment with iodide of potassium consists in giving full doses of this medicine once or twice a day until improvement is noticed, when the dose may be reduced or given less frequently. The size of the dose should depend somewhat upon the weight of the animal. M. Thomassen gives $1\frac{1}{2}$ drams of iodide of potassium daily in one dose dissolved in a pint of water until improvement is noticed, which, he states, is always within eight days. Then he decreases the dose to 1 dram. The animals do well under this treatment, showing only the ordinary symptoms which follow the use of iodine, the principal ones being discharge from the nose, weeping of the eyes, and peeling off of the outer layer of the skin. These symptoms need cause no uneasiness, as they never result in any serious disturbance of the health.

M. Godbille has given as much as 4 drams (half an ounce) in one day to a steer, decreasing the dose half a dram each day until the dose was $1\frac{1}{2}$ drams, which was maintained until the twelfth day of treatment, when the steer appeared entirely cured.

M. Nocard gave, the first day, $1\frac{1}{2}$ drams in one dose to a cow; the second and succeeding days a dose of 1 dram in the morning and evening, in each case before feeding. This treatment was continued for ten days, when the animal was cured.

Dr. Norgaard gave $2\frac{1}{2}$ drams, dissolved in water, once a day for three days. He then omitted the medicine for a day or two, and continued it according to symptoms. These examples of the treatment as it has been successfully administered by others will serve as a sufficient indication for those who wish to test it.

Experiments are now being conducted on a large scale by the Bureau of Animal Industry in the treatment of lumpy-jaw with this remedy, and the results will be published as soon as possible. In the meantime it would be well for all who have animals affected with this disease to treat them according to this method, and report results to the U. S. Department of Agriculture, Washington, D. C.

Arrangements were made at as early a date as possible to test the remedy on a large scale with the affected animals as they came to the Union Stock Yards at Chicago. As the State board was still exercising its assumed power to seize, quarantine, and slaughter affected animals, they were requested to release from quarantine all such animals arriving during the time necessary to collect the number which was desired for the experiment, and allow them to be taken without interference to the stables where they were to be fed and treated. This they agreed to do.

No sooner, however, was an attempt made to collect affected animals for the experiment than it was reported by the inspector of the department at Chicago that the State veterinarian was passing all these animals as fit for food except those in the very worst stages of the disease. This change in the policy of the State board made it difficult to obtain the necessary cattle for treatment, but some were collected, and these the board put in quarantine, so that they could not be taken out of the

stock yards. This action made it necessary for the Secretary of Agriculture to call upon the governor of Illinois for his interference, which was done in the following telegram:

Gov. J. W. FIFER,
Springfield, Ill.:

VIROQUA, WIS., August 23.

Have received following telegram from Dr. Melvin, in charge of meat inspection at Chicago: "Stock Yards Company refuse to allow cattle to go out of yards on orders issued by you or myself. Baldridge will have carload by Wednesday. They will only recognize orders of the State." Will you please instruct your live stock board to allow us to ship out all cattle for experiments in lumpy-jaw? I am anxious to have cattle in all stages of disease for experiment by Department's remedy. I am now two weeks behind in this work on account of not being able to procure cattle, and if I am to be subjected to further delay I will have to go to Kansas City to make experiments. Answer here.

J. M. RUSK,
Secretary of Agriculture.

To this request Governor Fifer replied in two telegrams, as follows:

Hon. J. M. RUSK, *Secretary of Agriculture,*
Viroqua, Wis.:

SPRINGFIELD, ILL., August 23.

I have directed the Illinois live-stock commissioners to allow your agents to ship cattle diseased with lumpy-jaw for experiments by your Department, as requested by you.

JOSEPH W. FIFER.

Hon. J. M. RUSK, *Secretary of Agriculture,*
Viroqua, Wis.:

SPRINGFIELD, ILL., August 29.

I am advised that the United States officials have full charge of the cattle in question, for the purpose of experiment, and are only held responsible for their safe-keeping. The officials of this State are seeking to exercise no control over them beyond this. Is not this satisfactory?

JOSEPH W. FIFER.

After the governor's assistance had been secured, the animals purchased were allowed to leave the yards for treatment, and a better class was obtained, but the influence of the State veterinarian was still exerted to prevent the Department from collecting the milder cases. Although animals so affected had been freely condemned before, they were now said to be either free from the disease or perfectly fit for food. Under such circumstances the owners naturally preferred to sell their affected animals on the market included in the lots with which they had been shipped.

Notwithstanding the obstacles put in the way of the experiment, 180 animals, in various stages of the disease, were finally collected and put under treatment. No sooner had the first lots arrived at the stables than they were placed in quarantine by order of the Illinois board of live-stock commissioners. This hostile action was also laid before the

governor by the Secretary of Agriculture, and on September 14 the quarantine was withdrawn by order of the governor. The following is the correspondence in the case:

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., September 6, 1892.

SIR: Allow me to thank you for your assistance in securing for me animals affected with actinomycosis for the purpose of experimenting with the same with a view to curing this disease.

As I telegraphed to you, your live-stock commissioners, immediately after I obtained these animals, placed upon them an order of quarantine, and I now write replying to your telegram asking whether said quarantine would in any way interfere with my experiments in this direction. I desire to call your attention in this connection to one or two facts. One of the purposes for which the Bureau of Animal Industry of the Department of Agriculture was organized was to investigate the diseases of domestic animals and to endeavor to ascertain the causes of the same and "means for the prevention and the cure" of animal diseases. At the same time, the Bureau was, by its organic act, empowered to extirpate all contagious and communicable diseases among the domestic animals of the United States and to enforce all necessary measures to prevent their spread. These being some of the purposes for which the Bureau was organized, it would seem that when it undertakes to carry on an experiment with a view to discovering a cure for some certain disease, that all necessary measures to prevent any danger of the spread of such disease from animals being experimented on would be provided by the officers of the Bureau. For a State board, therefore, to place in quarantine animals being experimented upon by the Department of Agriculture is not only unnecessary, but has the appearance of being discourteous. It is a reflection upon the honesty and ability of the officers of the Department. It is not to-day believed by any competent person that actinomycosis, the disease with which the animals that are now being treated at Chicago are affected, is a contagious disease, or that there is any danger of its being communicated from one herd of cattle to another or to people. There is consequently no danger to be apprehended from the animals now in the possession of the Department at Chicago undergoing treatment. The great public benefit sought to be obtained by the experiment is such that it should not be interfered with or impeded by hostile acts of State officers. It would seem as if State authorities should coöperate in every way possible towards the successful accomplishment of such a purpose, and not, from jealousy or other cause, seek to prevent its success. The quarantine placed upon these animals, which the National Government has bought and paid for and which are now its property, is to me exceedingly irksome, and I consider it almost a personal insult; not only that, but, in my judgment, it is an illegal quarantine, so far as it applies to the work which is being carried on by the Department in the State of Illinois. The Department of Agriculture is operating in Illinois under the provisions of the act of Congress of May 29, 1884, and of the act of the State of Illinois of June 28, 1887, and under these acts it is beyond the control or interference of State officials.

I would further say that in conversation with Mr. C. P. Johnson, secretary of the board of live-stock commissioners of the State of Illinois, I was informed by him, in a very gentlemanly manner, that the reason of this quarantine was that there was some liability on the part of the State in case any disease should be spread from these animals. I have to assure you that there is no such liability, and whatever liability there might possibly be is assumed by the National Government, and that the law of Illinois above referred to expressly provides in section 3 that the State shall not be liable for damages or expenses of any kind under the provisions of the

same, and that this Department will hold itself responsible for any damages that may be inflicted by reason of the experiment which is now being carried on.

This experiment is being watched with a great deal of interest, not only by the stock-owners of the State of Illinois, but by the stock-owners of the entire United States, for, in case it proves successful, it will be of great benefit to all owners of cattle. I feel assured that I will have your best efforts to prevent any impediments being placed in my way in carrying the experiment to a successful end, and I would therefore request that you will kindly have the quarantine order made by the live stock commissioners of your State at once rescinded.

Trusting that this request will meet with your approval, I am,

Very respectfully,

J. M. RUSK,
Secretary.

His Excellency JOSEPH W. FIFER,
Governor of the State of Illinois.

SPRINGFIELD, ILL., *September 14.*

Hon. J. M. RUSK,
Secretary Agricultural Department, Washington, D. C.:

The live-stock commissioners of this State will remove quarantine from the diseased cattle your Department is experimenting on in Chicago, as requested in your letter to me.

JOSEPH W. FIFER.

On November 29, 1892, eighty head of the cattle which had been under treatment were shipped to Chicago and slaughtered. There were two lots of forty each. The first lot was supposed to be nearly or quite all cured, while the second lot was made up of the worst cases, many still having large swellings upon their heads, which were believed to be incurable. By direction of the Secretary of Agriculture, the following notice was mailed to the governor:

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Chicago, Ill., November 26, 1892.

DEAR SIR: I am directed by Hon. J. M. Rusk, Secretary of Agriculture, to inform you that a portion of the cattle which have been under treatment for actinomycosis or "lumpy-jaw," will be slaughtered at the slaughterhouse of Jacob Hess, Union Stock Yards, Chicago, on Tuesday, the 29th instant. The Secretary will be pleased to extend every facility for examination to any inspectors or others whom you may desire to have present on that occasion.

Very respectfully,

D. E. SALMON,
Chief of Bureau.

Hon. JOSEPH W. FIFER,
Governor of Illinois,
Executive Mansion, Springfield, Ill.

There were present on the part of the State Mr. H. McChesney, of the Illinois board of live-stock commissioners; Mr. Johnson, the secretary of the board; Dr. Casewell, State veterinarian, and Drs. A. H. Baker and Joseph Hughes, assistant State veterinarians. There were

also present on the part of the city, Mr. Pierce and an assistant. The inspectors representing the Bureau of Animal Industry who were present were Dr. A. D. Melvin, inspector in charge at Chicago, and Drs. Lewis R. Baker and Victor A. Norgaard, all being under the direction of the Chief of the Bureau of Animal Industry. Dr. Melvin was instructed to make the inspection carefully, and condemn all carcasses about which there could be any doubt as to their fitness for human food.

When the slaughter began, the State veterinarian assumed to be in charge of the inspection; he put his assistants on the floor, and with them examined the various organs of the animals, cutting them open, and in some cases removing them before they were seen by the inspectors of the Bureau, and even, in some instances, directing the removal of such organs by the workmen of the slaughterhouse before they had been seen by Dr. Melvin, and without any consultation with the Chief of the Bureau, who was constantly present. Several times it was necessary to go to Mr. Hess, at whose slaughterhouse the animals were killed, and ask him to instruct his men not to remove the organs of any animals from the killing floor or from places where they could be identified, until Dr. Melvin had given his consent to such removal. A number of students of the Chicago Veterinary College, at which institution the two assistant State veterinarians mentioned are professors, had been brought there to witness the slaughter without the knowledge or consent of the Chief of the Bureau. A number of newspaper correspondents were also present, and as they did not get their information of the killing from anyone connected with the bureau, it is assumed that they were informed by some one connected with the State board. The result of so many persons being present who were unexpected was that the floor was crowded; the inspectors were obliged to work under difficulties, and it was only by exercising constant vigilance that the organs of the animals were examined before they were removed from the position where they could be identified with the carcass from which they came.

As long as these animals belonged to the Department of Agriculture, and were being slaughtered under its direction, it certainly was no more than courtesy demanded that those in charge should have been consulted before information was given to so many persons not officially connected with the State, in order that it might be determined whether or not their presence would interfere with the proper performance of the work in hand. In addition to this, those present on the part of the State did not hesitate to speak disparagingly of the experiment, freely stating that they were condemning as large a proportion of these carcasses as were condemned from the "lumpy-jaw" cattle which come to the stockyards and are slaughtered without treatment.

At the close of the day's inspection the State veterinarian, without consulting with the Chief of the Bureau or with Dr. Melvin, or with-

out informing the representatives of the Bureau what he had done, gave a certificate to the inspector present on the part of the city to the effect that eighteen carcasses which had been passed by the inspectors of the Bureau of Animal Industry, and tagged with the meat-inspection tag of this Department, were affected with actinomycosis. As a result of this the Chief of the Bureau was notified by the city inspector that these carcasses could not be sold for consumption in the city of Chicago.

It should be stated that, during the whole day, in spite of the offensive action above mentioned on the part of those representing the State, these gentlemen were treated with every courtesy and given every facility for making their examinations, and no disagreeable word was spoken in their presence by any one representing this Department.

The inspectors of the Bureau of Animal Industry condemned every carcass in which a lesion was found which was of sufficient importance to justify the least suspicion that the carcass would be affected by it. None of the eighteen carcasses passed by the United States inspectors and condemned on the certificate of the State veterinarian were affected in such a way as to cause any suspicion in the minds of any of the representatives of this Department as to the perfect wholesomeness of the carcass. The lesions in all were very small, in one case not being larger than a grain of wheat, and in every case being insignificant. In a number of the cases these lesions, when examined microscopically, were found to be free from the actinomyces fungus, and, consequently, in these cases, there was an error of diagnosis on the part of the State veterinarian. I have been informed by Dr. Melvin that cases with much larger lesions than existed in any of the eighteen cases mentioned have frequently been passed by the State veterinarian in his inspections at the stock yards and allowed to go on the market as fit for food. If the statement is correct, which was freely made, that no larger proportion of these carcasses were passed than were ordinarily passed among the lumpy-jaw animals which come to the stock yards, that of itself is sufficient evidence that the carcasses about which this unfortunate difference of opinion exists should have passed, because no animal without greater lesions than many of these had would have been held for examination.

From the statements made above it will be seen that the inspection made by the inspectors of this Department was entirely ignored, and that the State representatives, who were present by the courtesy of the Department and who have no responsibility as meat inspectors, assumed authority to certify as diseased the carcasses of animals belonging to the Department which the Government inspectors declared to be entirely fit for food. Considering all these circumstances, and particularly that Government property was at stake which these gentlemen had shown their determination to cause to be destroyed by misrepresentation, I decided that it was no longer my duty, either on the

grounds of courtesy or by any previous arrangement which had been made, to invite their presence when other animals belonging to the Government were to be slaughtered.

It may not be out of place to mention in this connection the fact, already referred to, that at the time these animals were being purchased the representatives of the State board apparently did everything in their power to prevent the collection of a sufficient number of animals for this experiment, and that in order to accomplish this, affected animals, such as had previously been condemned, were freely passed as fit for human food.

I am free to state that the disease with which these animals were affected when they were purchased for experiment—that is to say, actinomycosis or “lumpy-jaw”—can not properly be considered as a contagious disease, requiring any such action to prevent its spread as is being taken by the Illinois board of live stock commissioners. If the disease is contagious at all, which is doubtful, it certainly is not contagious to the degree which requires measures to prevent its dissemination by animals in transit for slaughter. There is no satisfactory evidence that it can be disseminated by animals mingling with each other in cars or yards, and it is even doubted by recognized authorities if it can be transmitted by inoculation, on account of the many failures which have been recorded.

In the International Congress of Hygiene and Demography, held at London a year ago, there was unanimity of opinion to the effect that there was no danger of this disease being transmitted to persons who used the flesh of animals so affected for food, and, so far as I remember, I was the only member of that congress who sanctioned the condemnation of carcasses of animals affected with this disease, except when it was disseminated throughout the body, and my position was that this was only justified when the malady had made such progress as to have affected the general health of the animal, as shown by loss of flesh or by large suppurating abscesses. In no other country than the United States, so far as our information extends, are carcasses condemned as unfit for food when locally affected with the actinomyces fungus, provided the animal was in good health and in good condition of flesh when slaughtered. The action of the Illinois State live stock commission in deciding this to be a dangerously contagious disease and in forcing affected animals with even slight lesions to be destroyed as unfit for food is, in my opinion, unjustified as a measure to prevent the spread of disease, and is a great wrong to the cattle producers of this country. There is no doubt that many thousands of dollars' worth of property have been unjustly taken from the cattle owners by such action. This would be the case, even if animals slightly affected were passed, as it is understood they have been in many cases. If, on the other hand, animals are to be condemned for the same reasons for which the eighteen carcasses above mentioned belonging to the Govern-

ment were condemned, then a much greater number of animals would necessarily be sacrificed. If a great department of the National Government can not secure justice in the inspection of animals belonging to it, when it has the undoubted authority to make such inspection with its own inspectors, then the individual shipper certainly has a very small chance to secure justice in the handling of his product.

In conclusion, I would ask attention to the fact that the Union Stock Yards of Chicago is one of the channels of interstate commerce; that the cattle received there do not come from the State of Illinois alone, but from nearly every State of the Union; that this is not their final destination, but that many of the animals and most of the products are shipped from there to other States. From these reasons it would appear that the United States Department of Agriculture should have jurisdiction in such yards, both to prevent the spread of contagious diseases and to insure a just and uniform inspection of animals and meats.

The experience in the slaughter of the animals belonging to the Department, and the action taken by the State veterinarian, evidently under the direction of the board of live stock commissioners, convinces me that there is much truth in the charges of arbitrary and inconsistent condemnation, and that something should be done by the United States Government to secure justice to the many cattle owners in various parts of the country, who are under the necessity of shipping their cattle to the Union Stock Yards of Chicago for market.

Of the eighty cattle slaughtered on November 29, forty-three were pronounced practically cured and fit for food by the inspectors of the Bureau of Animal Industry, and twenty-five were pronounced to be completely cured and fit for food by the State veterinarian. Considering that this number included forty of the very worst cases taken for experiment, the result can not but be considered as extremely satisfactory. If the conclusions of the Bureau inspectors are taken, the result is a cure of 53 per cent of the affected animals; while should we accept the extraordinarily biased report of the State veterinarian, we still find that over 31 per cent of the animals were completely cured.

The following report given to the press by the State board explains itself:

NO CURES OF LUMPY-JAW EFFECTED.

REPORT OF STATE VETERINARIANS ON EXPERIMENTS MADE IN CHICAGO.

SPRINGFIELD, ILL., December 7 (*special*).

The State board of live-stock commissioners to-day gave out for publication the following:

CHICAGO, ILL., December 5, 1892.

To the State Board of Live-Stock Commissioners, Springfield, Ill.:

GENTLEMEN: Tuesday, the 29th of November, at the request of Mr. McChesney, of your board, we, the undersigned, assisted in making post-mortem examinations of 80 head of cattle that were slaughtered in Hess Brothers' slaughterhouse in this

Referring to the reports of the board of live stock commissioners for the State of Illinois for the years ending October 31, 1889, 1890, and 1891, we find the figures given for the number isolated and the number condemned as follows:

	Number isolated.	Number released.	Number affected and slaughtered.
1889.			
Union Stock Yards.....	840	58	782
National Stock Yards.....	123	3	120
1890.			
Union Stock Yards.....	1,563	144	1,419
National Stock Yards.....	100	5	95
1891.			
Union Stock Yards.....	2,259	133	2,126
National Stock Yards.....	131	6	125
Total.....	5,016	349	4,667

This table shows that for three years there was less than 7 per cent of the isolated animals which were pronounced free from the disease. To explain even this number, considered by the board to be large, the following statement is made in their report:

The large number of animals released, as shown by the first table, is largely composed of those that were returned to the yards by the purchasers after they had reached the slaughterhouses, because they had a small lump, due to injuries, or other causes than actinomycosis, fearing that this would be made an excuse by the city health inspectors in the slaughter-house to cut down the carcasses, in which case the purchaser would have to bear the loss. All such cases turned back were inspected by our veterinarian, and we are advised that not a single one of these cases proved to be actinomycosis. (Annual Report of the Board of Live Stock Commissioners for the State of Illinois, 1890, p. 52.)

If during the years 1889, 1890, and 1891 the State veterinarian was so expert in determining actinomycosis in the living animal that less than 7 per cent of those isolated were found free from disease, and even these were mostly animals with small lumps due to injuries, turned back by purchasers and not by the veterinarian, how can we explain the sudden loss of this expertness in 1892 and the isolation of over 60 per cent of cattle which are afterwards pronounced free from the disease? This question is a pressing one at this time, for the statements of the board are inexplicable and inconsistent, and it is plain either that these statements are incorrect or that there has been an extraordinary change in the principles governing the inspection.

The animals taken for the experiment of the Department did not include any turned back by the purchasers on account of injuries, but every one was pronounced by the veterinary inspectors to be affected with actinomycosis. How, under such circumstances, the board can state that they have for months pronounced over 62 per cent of such cases to be free from the disease is a mystery and shows conclusively that

their action either in 1889, 1890, and 1891, or in 1892 was unskillful and lacking in uniformity or that they purposely modified their principles of inspection in order to disparage the results of this experiment. Whatever may be the final conclusion as to the cause of their action, the open hostility of the board has been apparent from the time the first animals were selected, and it has continued with increasing intensity as the success of the treatment became more and more apparent.

As the officiousness of the State inspectors made a proper inspection by the Bureau inspectors a difficult matter, and as the former assumed jurisdiction as meat inspectors which is not given them by law, and as finally they had shown a determination to cause the destruction of carcasses of cattle belonging to the Government, which carcasses were not diseased, I decided not to invite them to be present when the next lot of cattle was slaughtered.

On December 2 a lot of twenty head, all of which had been cured, were slaughtered at the same place, in presence of the Bureau inspectors above named and also of the inspector of the city department of health. Every one of these animals was free from disease, as was shown by the most careful post-mortem examination.

The examination of the one hundred head of cattle first slaughtered shows, according to the reports of the Bureau inspectors, who were unbiased and had no interest in the experiment beyond a desire to get accurate results, that sixty-three of these animals had been cured by the treatment. This is a cure of nearly two-thirds of the animals treated, and certainly can not be surpassed by the results of treatment with any of the internal diseases of a progressive nature which affect animal life. This is the more gratifying as some of the animals which were pronounced healthy by the State veterinarian had been affected with enormous tumors, which entirely disappeared during the course of the treatment.

The following correspondence in regard to the slaughter of twenty animals without notifying the State board explains itself:

STATE OF ILLINOIS, EXECUTIVE OFFICE,
Springfield, December 3, 1892.

DEAR SIR: Complaint is made to me by the live-stock commissioners of Illinois that on yesterday the second consignment of cattle delivered to your agent for experiment were slaughtered in Chicago without notice to the live stock commissioners of this State. I am also informed that there was an agreement previously entered into, when these cattle were taken for experiment purposes, that the live stock commissioners would be notified when said cattle were slaughtered, and afforded an opportunity to make a post-mortem inspection.

Permit me to call your attention to this complaint, believing that you will direct your agents in Chicago to carry out the agreement above named, and that, before slaughtering the remaining cattle under experiment, the commissioners will be duly notified and given an opportunity to make an inspection.

Yours, very truly,

JOSEPH W. FIFER.

Hon. J. M. Rusk,
Secretary of Agriculture, Washington, D. C.

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., December 6, 1892.

DEAR SIR: I am in receipt of your favor of the 3d instant, in which you state that complaint is made to you by the live-stock commissioners of Illinois that on December 2 the second consignment of cattle from the animals under experiment by this Department was slaughtered in Chicago without notice to such commissioners.

In reply I would say that this is correct and that, in order to give you a full statement of the reasons for such action, I inclose with this, for your information, a copy of the report made to me by Dr. D. E. Salmon, chief of the Bureau of Animal Industry, under whose direction the slaughter was made.

It appears from this report that the State veterinarian attempted to take charge of the inspection of the animals, that the inspection made by the inspectors of this Department was ignored, and that a certificate was given to the inspectors of the city department of health that eighteen carcasses were unfit for food which had been passed by the United States inspectors.

The invitation was extended to you by my direction, according to agreement, as an act of courtesy, to enable your representatives to witness the results of the experiment as revealed by the post-mortem examination, and every facility was given them for this purpose. Being there by invitation, their attempt to assume control and to enforce their unjust decision as to the disposition of the meat was an interference with the jurisdiction of this Department which could not be tolerated.

The Department inspectors were acting under the acts of Congress authorizing the inspection of meats, as well as the investigation and prevention of disease, and the test which they were conducting was to discover a cure in the interest of the cattle-raisers of the whole country. I am, therefore surprised to learn that the live-stock commissioners of Illinois and their assistants have gone, not only to the full extent of their authority, but beyond such authority, to obstruct and delay this experiment and to disparage its results.

I regret that the action of the commissioners, or those acting for them on the day mentioned, was such as to lead Dr. Salmon to the conclusion that he could not conscientiously invite them to be present at the slaughter on Friday, the 2d instant.

I think you will agree with me that if his statement of facts is correct, and I have no doubt it is as he understood them, that he could not properly have done otherwise.

The stand which is taken by the live-stock commissioners of Illinois in regard to the condemnation of these carcasses is a matter of great consequence to the stock owners of the United States, and it also involves property belonging to the United States Government. The inspection of animals for food should be uniform and just, and the meat inspection of this Department, which is authorized by act of Congress, and which is carried on by competent men, should be recognized. As the responsible officer in charge, I can not permit it to be ignored or called in question by State officials who are not even given jurisdiction as meat inspectors by the laws of the State.

Very respectfully,

J. M. RUSK,
Secretary.

HON. JOSEPH W. FIFER,
Governor of Illinois, Executive Mansion, Springfield, Ill.

Soon after this the chairman of the Illinois board of live-stock commissioners addressed a communication to the Secretary of Agriculture,

which was of so scurrilous and discourteous a character that it was returned to Gov. Fifer with the following letter:

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., December 19, 1892.

SIR: I inclose herewith a communication addressed to me by the chairman of the Illinois State board of live-stock commissioners, which not only refers to a number of matters with which he has nothing to do officially, but which is so discourteous in its tone that I must decline to receive it. If the board mentioned has anything to bring to the attention of this Department which you deem proper to transmit, I shall be glad to give it careful consideration, but I can not have any direct communication with a man in that position whose ideas of official courtesy are exemplified by such a letter as the one I return.

The letter in question is incontestable evidence of Mr. McChesney's unfitness for the office which he holds.

Very respectfully,

J. M. Rusk,
Secretary.

Hon. JOSEPH W. FIFER,
Governor of Illinois, Executive Mansion, Springfield, Ill.

To this the governor replied as follows:

STATE OF ILLINOIS, EXECUTIVE OFFICE,
Springfield, January 3, 1893.

MY DEAR SIR: I am in receipt of your favor of December 19, and contents noted. When I received your letter of December 6 I immediately called upon the board of live-stock commissioners of this State for a full and complete statement concerning their action in the matter of diseased cattle turned over to your Department for experimenting in the city of Chicago, and I inclose you a copy of their report to me on that subject, dated December 16.

I regret exceedingly the conflict that has arisen. I had no knowledge whatever, directly or indirectly, that Mr. McChesney would write you as he did under date of December 16, and I regret exceedingly that he did so. My administration closes now in a few days. The general assembly of this State convened to-day. I am very busy with official business that must be closed out before I give up the office to my successor. Were it not that my term of office expires in a few days I would give this controversy between the live-stock commissioners and your representatives further consideration.

Assuring you of my high regard and esteem, I remain, yours very respectfully,
JOSEPH W. FIFER.

Hon. J. M. Rusk,
Secretary of Agriculture, Washington, D. C.

The Secretary of Agriculture replied to the above letter and asked for the removal of the quarantine which the board had again imposed upon the cattle. His letter is given below:

U. S. DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D. C., January 7, 1893.

MY DEAR SIR: I am in receipt of your very satisfactory letter of the 3d instant, for which I wish to express my thanks. The report of the board of live-stock commissioners, which you state was inclosed, has not reached me, and for that reason I do not know what position they have taken in regard to the cattle belonging to this Department.

The chairman of the board, after writing his very discourteous letter to me, had the quarantine again put upon the cattle. I feel sure that you were not informed of this, or you would have taken action to cause its revocation. Up to the present it has caused me no embarrassment, because I was not ready to slaughter the cattle, but I wish now to have them slaughtered at once. I would request you, therefore, to have this quarantine removed, so that the cattle can be shipped to Chicago for slaughter the first of next week.

I am sure that you have been desirous of giving every facility for making this experiment, which is of so much interest and value to the farmers of your State and of the whole country, and that you are willing to do everything in your power to prevent delay in completing it, and giving the results to the cattle owners, to whom it is of vital importance.

There was no reason whatever for the board of live-stock commissioners to put a quarantine upon these cattle, because they knew very well that I would ship them to Chicago and have them slaughtered. Cattle affected with actinomyces are daily allowed to be shipped to the Union Stock Yards for slaughter, and, therefore, in case any of these are still affected, this Department is asking nothing beyond what is allowed without restriction to every cattle owner in the country.

I hope that the board of live-stock commissioners will no longer be allowed to maintain their position for the purpose of obstructing an investigation made as much in the interest of the people of your State as for the people of any other section of the country.

Assuring you of my appreciation of your courtesy in this matter, I am, very respectfully,

J. M. RUSK,
Secretary.

Hon. JOSEPH W. FIFER,
Governor of Illinois, Springfield, Ill.

INJUSTICE TO OWNERS OF LUMPY-JAW CATTLE.

Although the Illinois board of live-stock commissioners began quarantining and condemning cattle affected with actinomyces in 1888, it was not until their meeting of February 21, 1890, that they discovered that the owners of such cattle were only receiving from \$2.50 to \$4 per head for them. This was less than the value of their hides. Even at that late date the board did not make the discovery itself, but the facts were presented to it by a committee of the Live-Stock Exchange.

It is usually admitted that when the property of citizens is taken and destroyed for the good of the community, the citizen who suffers the loss should receive a just compensation, and the law of Illinois under which the board has acted provides for the appraisement and compensation for cattle destroyed to prevent the spread of disease. Although the cattle affected with actinomyces were ostensibly condemned to prevent the spread of that disease, it appears that no appraisement or compensation has been made as provided in the law. On the contrary, the destruction of these animals was enforced without any compensation from the State, and with no effort on the part of the board to see that the owners received even a just compensation from the parties who took possession of the carcasses. The owners were powerless. The cattle were seized and destroyed by order of the State board, and

the carcasses were turned over to the Union Rendering Company, which gave for them what it saw fit, and no more. The result was the owners were robbed of two-thirds or three-fourths of the value of their cattle even for rendering purposes.

According to the inspection rules of every country which carries on a meat inspection, and also according to the teachings of the most eminent scientists who have investigated the question, actinomycosis is generally considered a local affection, and in its early stages does not affect the general health of the animal or the wholesomeness of the meat. There is no good reason, consequently, for condemning animals in good condition which present only a small swelling on the jaw caused by the actinomyces fungus, and from which there is no discharge. In this case the part of the animal involved is not used for food, and when that is removed it is the general opinion of scientists that the remainder of the carcass is not affected. To condemn and destroy such carcasses as this is, therefore, unjustifiable from any point of view. It is especially uncalled for as an act to prevent the spread of the disease, as the most extreme believers in the contagion theory can not explain how the disease could be transmitted from an animal which had no discharge from the tumor by which the fungus could be disseminated.

It has not been uncommon to see steers in fine condition, weighing from 1,600 to 1,800 pounds, and worth 5 cents a pound, condemned because of a small swelling on the jaw which was scarcely more than visible. Such a steer would bring on the market for beef \$80 or \$90, but when condemned and delivered to the Union Rendering Company, the owner received, according to the board's own statement, not to exceed \$4. And this wholesale appropriation of the farmer's property was allowed to proceed for nearly two years before the members of the board became officially aware of what an outrage they were assisting to perpetrate.

Since that time a more satisfactory arrangement has been made, through the exertions of the Live-Stock Exchange. Under the new plan the carcasses are turned over to a rendering establishment in the stock yards, and the owner receives 1 cent a pound, less \$3 a head. That is to say, the owner of a steer weighing 1,600 pounds would now receive \$13 for the carcass. Even this is less than its real value for rendering purposes. In disposing of the cattle purchased by the Department for the experiment, no difficulty was found in getting offers of 1 cent a pound without any discount. An offer of this kind was received from the very firm which obtains the other cattle condemned at \$3 per head less. The conclusion is unavoidable, therefore, that the shippers of these cattle do not receive as much by \$3 a head as they are entitled to and as the carcasses are really worth.

If we should admit, which we do not, that the condemnation of the board is in all cases legal and justifiable, there would still remain this great wrong of forcing the owners of these cattle to take \$3 per head

less than they are actually worth when sold with an opportunity for free competition in the purchase. One would suppose that a board assuming the authority and the responsibility of making such seizures, would feel it incumbent upon itself to see that the owners were fairly treated in the disposal of their property, but apparently this is not the case.

THE JURISDICTION OF THE ILLINOIS BOARD OF LIVE-STOCK COMMISSIONERS OVER ANIMALS AFFECTED WITH LUMPY-JAW.

The Illinois board of live-stock commissioners is given no authority or duties by law in the inspection of meat. It was created to suppress and prevent the spread of contagious diseases among animals in the State of Illinois. Its powers to quarantine and cause the slaughter of animals is expressly limited by the statute under which it acts to animals affected with "dangerously contagious or dangerously infectious disease." Lumpy-jaw is, in the opinion of the State veterinarian, a dangerously contagious disease, and consequently the board assumes that it is fully empowered to quarantine and cause the destruction of animals so affected.

As many of the carcasses destroyed were plainly unfit for human food, being emaciated and in some cases affected with a more or less generalized form of the disease, there were many who were inclined to sustain the action of the board on this account, even if it should be shown that the disease was not "dangerously contagious" and consequently not within the intent of the law. However, the board did not confine itself to such carcasses, but seized animals in good condition, with only small lumps which were not discharging, and in general their actions were so arbitrary, dictatorial, and burdensome, that the cattle-owners of a large section of the country tributary to Chicago have been loud in their protests and vigorous in their demands for relief.

This situation raises the question as to whether the board has, under the Illinois law, any jurisdiction over animals affected with this disease—in other words, whether actinomycosis is a dangerously contagious disease, as stated in the opinion of the State veterinarian. To sustain itself the board has collected a number of reports of experiments in which it is alleged that the disease was communicated by inoculation with the tissue and discharge from the diseased parts of affected animals.

The reasoning appears to be that if a disease is inoculable it must be contagious, and if it tends to progress until the life of the animal is destroyed it must be dangerously contagious (Report, 1890, p. 20). This reasoning may be satisfactory to the board, but it will hardly be considered so by any unbiased scientist.

In the first place, a disease is not necessarily contagious because it is inoculable. Pyæmia, septicæmia, malignant œdema, black quarter, and tetanus (lockjaw) are all inoculable diseases, much more so than is

actinomycosis, and yet it is well known that these diseases do not spread by contagion from animal to animal, and they can not properly be regarded as contagious diseases. All of these diseases, with one exception, affect mankind, but it would be absurd to claim that people are infected from diseased animals because of the coincidence that man and animals both suffer from the germs of these diseases. It is well known that these germs exist nearly everywhere and that animals and men get them from the same source in nature. The actinomyces fungus is also widely distributed, and grows upon the straw and beards of grain, and probably upon grasses, and for that reason it must be almost universally present. Leading scientists have, therefore, concluded that, with this disease, as with lockjaw, the germs of the disease are obtained by man from the same sources as by animals—that is, from the sources in nature where they abound.

The next question which suggests itself is, what is meant by “a dangerously contagious or dangerously infectious disease?” The word “dangerously” is evidently an adverb qualifying the words “contagious” and “infectious,” and, as all words in a statute are supposed to have been put there for a definite purpose, we can only conclude that not all contagious and infectious diseases are meant, but only the dangerously contagious and dangerously infectious diseases, as stated. The meaning of “dangerously contagious” or “dangerously infectious” in this connection can only be taken as highly contagious or highly infectious, or at least having such a degree of contagiousness or infectiousness as to make the affected animals dangerous to the stock interests of the State.

The board says, however, that “no one will claim that actinomycosis is a highly contagious disease” (Rep. 1890, p. 20). They go on to say that “when the actinomyces have invaded the vital organs of the body, the disease, in both man and animals, is pronounced, by physicians and veterinarians, as fatal as tuberculosis, hence it must be listed in the catalogue of dangerously contagious diseases.”

This reasoning would make the word “dangerously,” which is an adverb, qualify the word “disease,” which is a noun. That is, it is assumed because this disease is dangerous and fatal, when not properly treated, that it is a “dangerously contagious disease.” But adverbs do not qualify nouns, and hence the word “dangerously” can only refer to the degree of contagiousness or infectiousness, and not to the fatal character of the malady. A disease may be extremely fatal, but not in the least degree contagious, and it may be very fatal and only contagious when purposely inoculated, as in the case of tetanus, or lockjaw, but it would be perverting the use of language to speak of either of these classes of disease as “dangerously contagious.”

It has been quite generally held by scientists who have investigated actinomycosis that it should be classed with those diseases which, like tetanus, or lockjaw, are produced by vegetable parasites inoculated by

hard bodies of various kinds which are infected, and which accidentally wound the skin, the mucous membrane, or other tissues, and thus gain entrance to the body.

There have been a number of cases recorded in which actinomycosis has been experimentally transmitted by inoculation from diseased to healthy animals. A large proportion of the successful inoculations were made with rabbits and guinea-pigs—animals which are very susceptible to most kinds of infection. In some cases large animals have been used, and with these the disease has been sometimes transmitted, and in other cases no result has followed the inoculation. The methods employed have been to deposit infectious matter in the abdominal cavity or in the connective tissue, or to inject it directly into the blood vessels. The results in most of the cases are of theoretical rather than practical value, because it is not likely that animals would be accidentally inoculated into the abdominal cavity or into the blood vessels. It is also an admitted fact with other diseases that those which require wounds of the skin and mucous membrane for the parasites to gain entrance to the tissues only in exceptional instances spread from animal to animal under natural conditions. So with actinomycosis, it is theoretically possible, but not probable, that an accidental inoculation might occur by which the disease would be transmitted from a diseased to a healthy animal. This contingency is too remote, however, according to our present knowledge, to give any warrant for considering the disease as dangerously contagious.

The Illinois board of live-stock commissioners admits that before suppuration sets in, and there is a discharge, the disease is probably not transmissible, naturally, from one animal to another. (Rep. 1890, p. 20.) This conclusion is incontestable, but in spite of it many animals, which did not have a discharge, have been seized by order of the board, taken from the owners and condemned to the rendering tanks. How the board can justify such action under a law which only permits it to quarantine and slaughter animals affected with a "dangerously contagious" or "dangerously infectious" disease, it is difficult to understand.

If this board actually believes that actinomycosis is a dangerously-contagious disease, its action has not been consistent with that opinion. Affected animals have been allowed to come freely into the Union Stock Yards to the number of 100 or 200 a month. They go into all of the pens, mix with thousands of cattle, and the action of the board, instead of hastening their slaughter, actually delays it and gives additional opportunity for contagion.

The diseased animals, instead of being slaughtered as soon as discovered, are placed in open pens, surrounded on all sides by healthy cattle, and are held in that condition until the end of the week, when the State veterinarian comes and decides as to whether they shall be condemned or not. There is no effort to clean and disinfect the pens

where the diseased animals have been, and I have, myself, seen the State veterinarian open abscesses of affected animals and allow them to drip pus by the pint into the public alleyways of the yards, where thousands of cattle were driven, without any thought of having this infectious material cleaned up or disinfected.

Instead of lessening the chances of infection in the Union stock-yards, the action of the State board actually increases it. Indeed, it is difficult to see how any one believing in the contagiousness of the disease would cause the affected animals to be held in the interior of such great stock yards from the beginning to the end of the week before they are disposed of, and equally difficult to understand how constant and thorough disinfection could be dispensed with. It is impossible to find any measures adopted by the board which are calculated to prevent the spread of the disease should it be contagious, but on the contrary, the measures enforced, as already stated, are of such a nature as to assist the dissemination of contagion.

The board has devoted considerable space in its reports to arguments by which it attempts to show the danger to consumers of the meat of animals affected with actinomycosis. Their extravagant statements have excited the wonder and ridicule of sanitarians the world over. It would appear from the attention which the board has given to this aspect of the question, from the condemnations by it of some carcasses of affected animals and the passing of others as fit for food, from the neglect to disinfect cars, yards, and alleys where diseased cattle have been, and from the holding of diseased cattle in the stock yards a whole week for the visit of the State veterinarian, that its action in regard to lumpy jaw is a meat inspection measure and not a measure for the purpose of preventing the spread of a contagious disease among animals.

The board, however, has no authority to inspect meat, but was created for the purpose of "the suppression and prevention of the spread of contagious and infectious diseases among domestic animals." When it goes beyond this purpose, it would appear to be acting outside of the law, and it certainly causes great and unnecessary hardship to cattle owners in holding their animals a whole week for inspection. If there is to be a State meat inspection applied to cattle in the interstate trade, that inspection should be promptly made by competent inspectors, and there should be an end to this ridiculous method by which suspicious cattle are collected for a whole week by employes ignorant of the nature of cattle diseases, and then passed upon by the State veterinarian by a cursory examination on Saturday. An inspection of value to the consumers or satisfactory to the producers can not be conducted in yards where from 50,000 to 75,000 head of cattle arrive weekly, by a single veterinarian, who devotes but one day in the week to this duty.

The important question in this connection is as to whether the board

has jurisdiction for the inspection of meat. If it has not, then its acts in condemning animals and meats for the purpose of preventing certain carcasses from going on the market for food can only be considered as illegal. In that case there would be no need of considering whether or not actinomycosis might be communicated to the consumers of the flesh of affected animals, as the question at issue would turn on the jurisdiction of the board, and the cattle owners would thus secure relief.

The danger of the transmission of this disease to people from affected animals has been insisted upon by the board in such unequivocal terms, however, that a public interest has been aroused which makes it desirable to quote the opinions of some of those unbiased scientists who have given most attention to the subject. Actinomycosis in people is a very rare disease, and but few cases are on record as having occurred in this country. If there were any great danger of its being communicated by the flesh of affected animals we should certainly expect that it would be more frequent. On the other hand tuberculosis is one of the most common diseases of mankind, and is known to be communicable among animals by taking tuberculous germs with the food, and yet, as appears from Dr. Norgaard's report attached hereto, the inspectors of the State board and of the city health department pay no attention to meat that is covered with tubercles even when it is exposed to their view in the slaughterhouses. Tuberculous meat is incomparably more dangerous than that of animals affected with actinomycosis, and, hence, it is difficult to understand this inconsistency in the action of inspectors who claim to be so solicitous for the public health.

Prof. Crookshank, in the course of an exhaustive review of our knowledge of actinomycosis, published in the annual report of the agricultural department, privy council office, on the contagious diseases, inspection, and transit of animals for the year 1888, says, by way of conclusion:

The successful transmission of actinomycosis from man to bovines suggests inter-communicability, but the negative evidence as to infection of man from bovines supports the view that the disease is derived from some source which is common to both species. (S. C., p. 115.)

In summing up the evidence as to the source of the disease in man, he says:

Many interesting observations have been made upon the origin of this disease in man. Two cases have been recorded in support of the theory of direct infection from the cow. Stelzner described a case of the actinomycosis in a man who had had the care of animals some of which had suppurating glands. Hacker had a case of the tongue in a man who had charge of cows, one of which had a tumor of the jaw, which he had opened. On the other hand, Moosbrugger found that out of 75 cases 54 were in men and 21 in women, including 2 children. In 11 of these the occupation was not stated. In 33 their occupation did not bring them into contact with diseased animals. They were, for example, millers, glaziers, tailors, shop people, and students. Only 10 cases occurred among farmers, peasants, and farm laborers. In 1 case only out of the 10 had the patient been in contact with diseased animals.

Out of the 21 women there were only 4 peasants, and none of them had been associated with diseased cattle.

Infection by the flesh of diseased animals has also been discussed, but there is no evidence of the prevalence of the disease among slaughterers and butchers, who would be particularly liable to it if flesh were a source of infection. The chances of infection by ingestion are minimized by the flesh being almost always cooked. Actinomycosis occurs also in pigs, and pork is often eaten in an uncooked state, but Israël has pointed out that this may probably be excluded, as many of the cases occurred among strict Jews.

The evidence points to the disease originating in man and lower animals from the same source, and there is a very strong suspicion attached to cereals. This view is supported by important observations with reference to the part played by cereals in inducing the disease in cattle, which have already been mentioned, and it gains additional support from a case described by Soltmann, where the disease resulted from swallowing an awn of barley. A boy, aged 11, accidentally swallowed an awn of *Hordeum murinum*. He became very ill and suffered great pain behind the sternum, extending over six intercostal spaces, and when opened the awn of barley was found in the evacuated pus. The pain, however, continued and fresh deposits occurred, and when the boy was taken to the hospital the ray-fungus was detected. Possibly the spores of the fungus can be conveyed both by air and water.

Friedberger and Fröhner, in the last edition of their excellent Treatise on the Special Pathology and Therapeutics of the Domesticated Animals, published in 1892, give the following unbiased opinions, which they form from the scientific investigations made up to the present time:

Experiments to transfer the same to other animals have been made by several parties, but were always unsuccessful (Rivolta, Bollinger, Seidamgrotzky, Perroncito, John, Ullmann, Bodemer, Boström). Cattle, calves, goats, sheep, wethers, hogs, dogs, cats, rabbits, guinea-pigs, did not suffer after inoculation; only in some cases a granulation, outlined by inflammation, developed as the reaction of the organism against the inoculated foreign bodies. The alleged positive results of inoculation of Ponfik, Israël, Rotter, and Hanau refer, according to Boström, only to inoculation material which remained and was encysted (encapsuled). It appears that the actinomyces fungus produces a pathogenic effect only in that stage of development reached in connection with the beards of grain; but when once introduced into the animal body it is no longer transferable, because it immediately assumes involution forms (calcification) after inoculation. The negative results of the inoculation experiments are of great importance for the solution of the question whether or not a transmission of actinomycosis occurs from animal to animal or from animal to man. All are of the opinion that an infection of this kind does not take place (p. 585).

Inspection of meat.—As already mentioned in the article on "Pathogenesis," it must be considered as very improbable that the actinomycosis is a contagious or an infectious disease in the sense of its transmission from animal to animal or from animal to man. A case of infection of man from cattle affected with actinomycosis has never been observed which was free from all objections. At the most, such a transmission may be considered perhaps as possible from a theoretical standpoint, but not as probable. Experience is positive against the occurrence of a direct transmission. The actinomycosis, therefore, in relation to the inspection of meat is by no means so important as tuberculosis, even setting aside the fact that the former usually represents only a local affection. The meat of cattle affected with actinomycosis may be commercially disposed of without hesitation after the affected parts have been removed; it is objected to only in the rare cases of a generalized actinomycosis (p. 592).

Ostertag, in his handbook of meat inspection, published in 1892, says, after reviewing the evidence at hand:

According to this, we are hardly justified in assuming that the use of actinomycotic organs as food is injurious to health. At any rate, we must deny the possibility of this for the meat of actinomycotic animals. The activity of the sanitary police should therefore be restricted to the detection of all organs affected with actinomycosis, and the withdrawal of them from the market as highly spoiled food products in proportion as the specifically changed portions can not be certainly removed. In isolated lesions in the tongue this will usually be possible, and is further recommended, as the tongue is a valuable organ. In cases of generalization the whole animal is to be withdrawn from the market, because the generalization in actinomycosis seems to have an entirely atypical cause, and the detection of the total lesions (in the bone, in the depth of the muscles) is much less easy than in tuberculosis, in which the regular lymph gland affection answers as an excellent guide for the discovery of the diseased areas.

Prof. Thomas Walley, in the second edition of his very thorough Practical Guide to Meat Inspection, published in 1891, says (pp. 135-387):

The malady affects man, and is in him known as *actinomycosis hominis*, and while it has been transmitted by inoculation from man to the calf (Crookshank), so far as I am aware there is no direct evidence of the transmission of the disease from animals to man. Nor indeed is such a contingency ever likely to arise, seeing that the vitality of the spores of the hyphomycetes is much inferior to those of the pathogenetic fungi, and that the changes produced by it in the organs attacked are so marked as to attract the immediate attention of even ordinary persons; and what is of more importance, the lesions of the disease are seldom localized, except in the pig, in the muscular tissue of the body. * * * Although certain organs, such as the tongue, may be largely involved, there is not much accompanying fever or interference with the normal functions or with the nutrition of the blood, and any systemic changes that arise are due mainly to annihilation of the functions of the tongue, or of the particular organ involved, and as a result of this a state of poverty is induced. Seeing that the disease is rarely of a systemic nature, and that there is an absence of fever, the nutritive changes induced in the muscles are so slight as to do away, in the great majority of cases, with the question of nocuity of the flesh; but, notwithstanding this, if there is any evidence of malnutrition of the blood or of the flesh, the carcass should be condemned for human food and in every instance the affected organ or organs should be effectually destroyed.

EXPERIMENT TO TEST THE CONTAGIOUSNESS OF ACTINOMYCOSIS.

When the cattle affected with actinomycosis were placed under treatment 21 healthy cattle were placed among them in the stables in such a way that they would be most exposed to the infection of the disease. The healthy animals were tied between diseased ones, where they were obliged to eat food soiled with the discharges from the tumors, and where they could not but inhale the breath warm from the lungs. There would appear to be no way possible of making a more severe test, and yet after being in such proximity with diseased animals for four months not a single one showed signs of being affected either while alive or on post-mortem examination after they were slaughtered.

EFFECTS OF IODIDE TREATMENT.

DOES THE IODIDE TREATMENT DRIVE THE DISEASE TO THE INTERNAL ORGANS?

In a weekly agricultural journal printed in Chicago appeared a statement, under date of December 7, 1892, of the results of the post mortem examinations made of the eighty cattle slaughtered on November 29. This statement was evidently inspired by the State veterinarian or one of his assistants, as the post mortem notes of each case as taken by these officials were given in full. In this statement occurs the following language:

From the experiment just concluded we learn conclusively that iodide of potash has an effect upon cattle afflicted with actinomycosis, and possibly that it may cure simple cases characterized by glandular swellings or abscesses not attached to the bone. The general effect, however, is more of a dangerous than beneficial character as regards severe cases of lumpy jaw, where suppurating tumors implicating the bones are noticeable about the head. Used in such cases iodide of potash apparently causes a superficial drying up of the suppurating sores which might lead the owner to believe that a cure had been accomplished, when, on the contrary, such external effects are no safe criterion of internal conditions. The post-mortem examination of animals so healed externally developed serious trouble within, trouble that had evidently been carried by the blood and possibly driven inwards by the drug employed.

The question now is, was there anything in the results of the examination to justify the conclusion that there were more internal lesions than are usually found in animals affected with actinomycosis? So far from this being the case, there was a very much smaller proportion of the animals affected internally than was to be expected. The State veterinarian and his assistants are certainly the last people who would be expected to give the impression that a larger proportion of these animals were affected internally than is usually found.

The following table is compiled from the reports of the Illinois board of live-stock commissioners for 1890. It shows the proportion of untreated animals which were found affected in the lungs or abdominal organs:

Date of examination.	Number of animals examined.	Number affected internally.	Page of report where recorded.	By whom examined.
Mar. 11, 12, 1889	5	5	17	Dr. Baker.
Dec. 6, 1889	3	3	27	Drs. Casewell, Scott. Williams, Page.
Aug. 11, 1890	55	43	19	Drs. Baker and Hughes.
Aug. 14, 1890	34	23	19	Do.
Total	97	74		

Fully 76 per cent of these animals were, therefore, affected in lungs or abdominal organs. Now, taking the notes of the State inarian as published in the paper above mentioned, we find that admit fifty-five of the animals had actinomycosis at the time of ter, while they found lesions of the lungs and abdominal organs twenty-three; that is, turning all the facts so that they will

much as possible towards this view that the iodide treatment tends to develop the disease internally, we find that, of the fifty-five affected animals which had been treated, but 42 per cent were affected internally, as against 76 per cent found with untreated animals by the State veterinarian and his assistants.

This, however, is not a fair statement of the case, because eighty animals, every one of which had the disease before treatment, were examined, and of these only 28½ per cent were found affected internally at the time of slaughter. And this is taking the statements of men who were doing everything in their power to disparage the results of the experiment and make it appear valueless.

As a matter of fact, the statement referred to which was printed from the notes of the State veterinarian does not correspond with the records of the bureau inspectors. Dr. Norgaard dictated a record of the condition of each animal as examined to a stenographer as the examination was made, and this record is the only accurate one that exists. From this official record it appears that seventeen of the animals reported by the State veterinarian to have internal lesions of actinomycosis did not have such lesions. Some of them had small nodules along the intestinal walls, which are common in healthy cattle, but when these were examined microscopically they were shown not to be affected with the actinomyces. There are several other cases reported with internal lesions, the numbers of which do not correspond with the numbers of any of the cattle slaughtered. There was evidently an error in printing the numbers of these animals, and I am unable for that reason to compare the notes with those made by Dr. Norgaard. Taking the examination made by Dr. Norgaard, therefore, as a basis for calculation, we find that among the eighty cattle killed on November 29 there were but four which showed internal lesions caused by the actinomyces fungus. As twenty additional animals were killed and examined on December 2, in none of which any trace of internal lesions was found, the result was that in the 100 animals first slaughtered but 4 per cent showed evidence of the disease having affected the internal organs located in the thorax and abdomen.

The proportion of animals affected internally was very much less than was expected, and it is conclusively demonstrated by this fact that the iodide of potassium reduces the proportion of internal lesions and that it has fully as wonderful an effect on these as it has on the external lesions. This is precisely what we should expect from internal and constitutional treatment. If the remedy had been applied externally and caused the tumors to heal from the surface, there might have been some reason for anticipating a change of the seat of disease from external to internal organs. Being, on the contrary, administered internally, the remedy penetrated the whole organism, acting upon the internal organs at the same time as upon the external tumor, and the effect was not only to prevent the extension of the disease, but to cure any manifestations of it which may have existed in the interior of the body.

It can not be stated too emphatically nor repeated too often that the State veterinarian and his assistants carried out their examination with the determination to disprove the results of the experiment. Every inch of the intestines and every portion of the internal viscera were scrutinized in the most deliberate and anxious manner. The least abnormal sign, though it affected tissue of no greater magnitude than the head of a pin, was set down as a serious internal lesion caused by the actinomyces. Inspection of Dr. Norgaard's notes will show that in a number of cases these lesions were examined microscopically and were proved to be free from the actinomyces germs. Anyone who examines the intestines of healthy cattle will find in their walls, in a considerable proportion of cases, such small tumors, which have not the slightest effect upon the health, and which in many cases are caused by animal parasites. To set these down as internal lesions of lumpy jaw is to show either deplorable ignorance of the subject or deliberate falsification of the facts.

On January 23, 1893, the Secretary of Agriculture informed Governor Altgeld that the cattle remaining in the experiment were ready for slaughter, and requested the removal of the quarantine for that purpose. The governor immediately replied by telegraph that he had directed the board of live stock commissioners to permit the removal of the animals.

The eighty-five animals which had been under treatment were slaughtered on January 27 and 28 at Hess Brothers' slaughterhouse. There were present, besides the Chief of the Bureau of Animal Industry, the following members of the Bureau force: Dr. A. D. Melvin, chief meat inspector at Chicago; Dr. W. S. Devoe, chief inspector for New Jersey; Drs. V. A. Norgaard and L. R. Baker, meat inspectors at Chicago; Dr. M. R. Trumbower, State veterinarian of Illinois, and the inspectors of the Chicago department of health.

The number found on post-mortem examination to be cured was sixty-eight, or 80 per cent of the whole number. Of the seventeen condemned as not cured there were internal lesions of actinomycosis in the lungs of three. About $4\frac{1}{2}$ per cent of this lot of animals, therefore, showed internal lesions.

Of the whole number under treatment, which were killed and examined, viz, 185, there were found to be cured 131, or about 71 per cent. The number showing internal lesions was 7, or 3.8 per cent of the animals in the experiment.

This result is extremely gratifying, and proves that a large proportion of the advanced cases of actinomycosis are curable by the internal administration of iodide of potassium. If taken in the early stages of the disease, there is no doubt that 85 or 90 per cent would yield to this treatment.

THE COST OF TREATMENT.

It has been repeatedly stated by those who have opposed the Department in its effort to relieve the cattle owners from the injustice which has been practiced upon them at Chicago, by giving them a specific treatment for this disease, that farmers can not afford to use a medicine for this purpose which costs \$3 a pound. Let us examine this statement in the light of the facts.

The result of the experiment shows that about two-thirds of the lumpy-jaw steers which come to the stock yards can be cured. If they were taken in an earlier stage of the disease the proportion would be much larger. Taking, however, two-thirds as a basis of calculation, we will see what would be the result on twelve animals averaging 1,200 pounds in weight. If shipped without treatment and condemned they would bring \$9 per head, or \$108 in all. If treated with the same success as the animals in the Department's experiment, there would be eight cured ones, which would bring not less than 4 cents per pound in good flesh, or \$48 per head. This would amount to \$384 for eight head, to which should be added \$36 for the four not cured, making a total of \$420 receipts as against \$108 if not treated. The medicine does not cost over 7 cents for each day it is administered, and no animal should receive over one pound in all. Taking the largest figures and the medicine for treating twelve steers would cost \$36. Deducting this from \$420, we have remaining \$384, a gain of \$276 in all, or \$23 per head over what would have been received if the cattle were not treated. It must be plain to every experienced cattle-feeder that there is no other known medicine, nor indeed any kind of food, which can be given to his animals with a prospect of such returns for the money invested.

It is difficult to understand the motive which will lead men to make such absurd objections and such incorrect statements in regard to a discovery which must prove of such incalculable advantage to the farmer without in the least injuring any other class of our citizens. It appears, however, that certain parties have committed themselves so irrevocably to the position that actinomycosis is a dangerously contagious and incurable disease that they are willing to go to almost any length to prevent the overthrow of this theory. The action of the Illinois live stock commissioners, for instance, made it difficult to obtain cattle for experiment. They quarantined the cattle in the stock yards so that until the governor interfered they could not be taken to the stable for treatment. After the cattle were taken to the stables they were again put in quarantine until the governor ordered them released for a second time. Incorrect reports were sent out apparently on authority of the board, giving the impression that the results were less favorable than was actually the case. Other statements were made as to the proportion of isolated cattle condemned by the board, and as to the proportion affected internally, which are at variance with the rec-

ords given in the printed reports; and after the quarantine was removed from the cattle under experiment it was again imposed on December 31, when the results of the first killing became known. If these several actions were not taken in the first place with a view to preventing the experiment being made, and afterwards to disparage the results obtained, and to delay the completion of the test, it is impossible for me to explain them on any other hypothesis.

SUCCESES OBTAINED BY INDIVIDUALS WITH THE IODIDE TREATMENT.

A considerable number of cattle-feeders have tested the treatment of actinomycosis with iodide of potassium, and their results, so far as reported, have been remarkably successful. Below are given some of the letters received:

BRADFORD, STARK COUNTY, ILL., *November 21, 1892.*

U. S. DEPARTMENT OF AGRICULTURE:

In October I received a circular giving treatment for actinomycosis. I tried it on three head of cattle, and it worked to a charm. I told other cattlemen, and several have tried the treatment. All are well satisfied but one, who informs me that he could see no change. His steer was very bad. The three I treated had not fully developed, and the veterinarian could not operate at the time. I therefore commenced treatment, and all swelling of the throat disappeared.

Yours, truly,

R. W. PHELPS.

VAN BUREN, ILL., *November 22, 1892.*

BUREAU OF ANIMAL INDUSTRY,

Washington, D. C. :

I treated three 3-year-old feeding steers according to the advice contained in your circular of October 10, 1892, for actinomycosis, or lumpy-jaw, with iodide of potassium. One had a lump under the ear; one on the jaw, and one under and between the jaws. The first was 3 inches in diameter; the second about 3½ by 6 inches long, and the third about 5 inches in diameter. I commenced with 2 drams daily, and increased to 3 drams for twelve days, when the first named was entirely cured. I then gradually decreased to 1½ drams, and at the end of sixteen days the second was cured, the third being cured on the twenty-first day. The three head were all slaughtered at Chicago thirty-five days from commencement of treatment.

Yours, very respectfully,

L. A. KEENE.

WELTON, CLINTON COUNTY, IOWA, *November 26, 1892.*

DR. D. E. SALMON,

Chief of the Bureau of Animal Industry :

I received a circular from your Bureau on October 18, with instructions for the treatment of lumpy-jaw in cattle with iodide of potassium. The cow I treated is 4 years old, and was bought at a sale for a trifle on account of her jaw. I thought I could cure it with corrosive sublimate, but failed. The jaw had been affected for a year before I began the iodide of potassium treatment. I had it lanced several times,

and for two months it had been running almost constantly. I began the treatment on October 22, and gave 1½ drams every morning for ten days, then every alternate morning for a week, and the lumps are gone and the sore healed up. The cow now appears to be beginning to thrive. In this case, and it was a radical one, the treatment has been a positive success.

Respectfully yours,

JOHN HOWAT.

KING CENTER, MO., *December 2, 1892.*

DEAR SIR: I have been reading of your experiments with iodide of potassium. I would like to tell you of my experience with it. I have been treating "big-jaw" with it for more than a year, and have cured more than twenty cases. . . .

A. J. WHEATLEY.

Hon. J. M. RUSK,

Secretary of Agriculture, Washington, D. C.

CRESTON, IOWA, *December 5, 1892.*

DEAR SIR: I tried your remedy for lumpy-jawed cattle on five steers out of my herd, and it has proved successful in each case.

DANIEL D. DORN.

Hon. J. M. RUSK,

Secretary of Agriculture.

WARSAW, IND., *December 19, 1892.*

DEAR SIR: Some two months ago I asked the Department for a bulletin on "lumpy-jaw." I had a 2-year old Durham heifer with a lump on her jaw the size of a small hen's egg. I purchased 1 ounce of the prescribed remedy, iodide of potassium, divided it into eight portions, and gave as directed, in bran. I saw no change except the softening of the tumor. I bought another quantity, and after a rest of a week gave it in the same manner. The lump has disappeared, except a small callos. The animal's eyes became weak, which is the only change I could see. The last ounce of the remedy I gave in seven doses. I think the heifer is cured of the ailment.

Yours,

A. T. COOK.

Dr. D. E. SALMON,

Bureau of Animal Industry, Washington, D. C.

ALGONA, IOWA, *December 18, 1892.*

DEAR SIR: I cured two lumpy-jaw heifers, a 3-year old and a 2-year old, giving each 1 ounce of iodide of potash, in six doses, two months ago, and as yet there is no sign of a return of the disease.

Very respectfully,

R. W. BARRETT.

Hon. J. M. RUSK,

Secretary of Agriculture.

KIANTONE, CHAUTAUQUA COUNTY, N. Y., *January 2, 1893.*

DEAR SIR: Some time ago we wrote you, asking if the Department had ever made an investigation of the lumpy-jaw in cattle, and we received in reply a circular containing the iodide of potassium remedy, and asked us to report results. We had two cases.

No. 1, a cow in milk, was taken in July. Had four different sores that discharged matter previous to treating her with this remedy. A local veterinarian had advised killing her. One of the sores has entirely healed; the other three are greatly diminished in size. Her flesh has dropped off until she is getting quite thin, and is at the present time and has been for the last three weeks, very stiff. Her eyes discharge very badly; nose but little, and the outer skin looks as if some one had poured her hair full of the coarsest bran. Her appetite is as good as any cow we have.

No. 2, a cow also in milk when taken, but dried off since. She was taken about middle of November, one bunch only. It did not discharge until broken by halter pulling on it. Had treated her ten days. The matter discharged was white, with a yellowish cast, and was very thick and sticky. She discharged from the nose very badly, and also from the eyes, but the outer skin cleaving off was hardly noticeable in this case. She did not drop off in flesh, nor did she show any stiffness. The sore has greatly diminished in size, and think we will have to give her no more medicine, as all that remains is apparently dead flesh, and does not seem sore. We are highly pleased with the remedy so far.

Yours, truly,

S. SPENCER & SON.

Hon. J. M. RUSK,

Secretary of Agriculture, Washington, D. C.

VINE HILL, CONN., *January 27, 1893.*

Patient, thoroughbred Guernsey; age, 8 years; calved July 11, 1892. Observed bunch on left upper jaw November 1, 1892. At this time enlargement was about size of two fists, and very firm. Herdsman then reported to me he had observed swelling in August, 1892. For four days after November 12, administered 2 drams iodide of potassium twice daily. One week later repeated same doses for same period of time. From November 30, for seven days following, gave 2 drams once daily. About one week thereafter administered 1 dram once daily for ten days. From November 12 the swelling rapidly increased in size until November 27, when at about the size of a man's head, it broke. In a few days indications of resolution set in, and for the past six weeks she has, to all intent and purpose, appeared to be perfectly recovered. At this date, the seat of attack is barely visible. The cow's appetite improved shortly after receiving first dose of the iodide, and milk secretion also increased.

F. H. STADTMUELLER,

One of the managers of Vine Hill and Ridge farms, West Hartford, Conn.

FONTANA, MIAMI COUNTY, KANS., *February 1, 1893.*

DEAR SIR: I have tried iodide of potassium for the cure of lumpy-jaw in cattle on 12 head, as prescribed under the treatment made by your direction at Chicago. Nine head, are entirely well; three need further treatment. Five head, with large, lumpy jaws, would have been worthless without the iodide cure. The balance might have got well without it, as they had only bad lumps. I have full 400 head of cattle this winter, and will not have a worthless steer amongst them. The experiment made by your direction has saved me \$200 or \$300. John Shean lost 10 out of his herd of 100 head from lumpy-jaw. He then tried the iodide of potassium remedy on two

very bad cases, and cured them. I know lumpy-jaw can be successfully treated by farmers and feeders with iodide of potassium. Accept my thanks for the interest you take in the welfare of farmers.

Respectfully, yours,

FRED. MATHEWS.

Hon. J. M. Rusk,

Secretary of Agriculture, Washington, D. C.

Mr. J. W. Wampler, a stock-breeder of Brazilton, Kans., in a letter recently published in the *Kansas Farmer*, says:

I will tell you all I know about curing lumpy-jaw in cattle. Last summer I saw an account in some paper that Secretary Rusk wanted 300 head of lumpy-jawed cattle to experiment on, and he thought he could cure them. I wrote him to send me his remedy and I would experiment, too, as I had three of my own, badly diseased. In a few days I received his answer, and also the remedy, and how different cattle had been treated.

The remedy is iodide of potassium. It costs 30 cents per ounce here in Girard, and 1 ounce will cure one animal if the disease has not gone too long. The longer the disease has run, the more of the iodide of potassium it will take. I use 1 dram in 1 pint of fresh water. It dissolves readily if well pulverized. This much I give to each animal every morning. Don't mix any more than you use each day, as it is better while fresh. Place a good leather halter on the animal and draw its head up by placing the strap or rope over something above. Place a cow horn in its mouth, then pour the medicine through. Repeat every morning unless the animal gets to running too much at the nose, so much that it interferes with its breathing, then stop a day or two, and commence again, and so on, until the animal is well, which, if the disease is not too old, will be in ten or fifteen days.

I have a fine heifer that was badly affected for over a year. The lump on the left side of her head was half as large as her head, and had become honeycombed and running. I fed her 5 ounces and then quit, thinking the disease had gone too far, and left her run, thinking I would kill her and drag her away. We were busy sowing wheat, and did not notice her for some two weeks. I then went to look at and arrange to kill her, as I did not want her to be with the other cattle, but was surprised to see the lump half gone and the remainder soft, and it has been going away ever since, and now she is well.

I cured two steers, also, that had not run so long. One I fed 1 ounce and the other about 2 ounces. I told a neighbor that had three badly diseased. He cured them all. Another neighbor cured three. Another had one that was fat, but had a lump on jaw. He tried to sell it to a shipper, but he would not take it for a gift. He tried the remedy, and in two weeks she was well. He sold her and she went to Kansas City, passed the inspection, went on the market, and he got a good price for her.

Don't get scared if they run at the eyes and nose and the outer coat of skin peels off, like the hair was full of bran, for this is characteristic of the effects of the iodide. The cattle will fatten while under treatment, and so much better and faster afterward, that I am convinced that it would pay to treat all cattle to about 1 ounce to purify the blood and system, especially those put up to feed.

I have given to others that I have not heard from yet, except one that had two steers. I saw him the other day, and asked him how he succeeded in curing the jaw? He said he had bought the medicine and laid it up in the kitchen and it was there yet. So you can see his cattle have the lumpy-jaw yet. I will give anyone all I know about curing lumpy-jaw if they will let me, inclosing stamp, and not charge anything, feeling that what is good for my neighbors.

Dr. V. A. Norgaard is hereto appended.

REPORT OF DR. V. A. NORGAARD, INSPECTOR IN CHARGE.CHICAGO, ILL., *February 6, 1893.*

SIR: I have the honor to submit herewith a report upon the results of experiments in the treatment with iodide of potassium of cattle affected with actinomycosis.

Very respectfully,

VICTOR A. NORGAARD,
Veterinary Inspector.

DR. D. E. SALMON,
Chief Bureau of Animal Industry.

THE MEDICINE.

It has already been mentioned that the medicine used in treating actinomycosis is iodide of potassium. This is a common drug and may be obtained at any drug store, the price being about \$3 per pound.

All the iodine salts have a faint antiseptic power, which is produced by the iodine getting free under a prolonged influence of various organic substances. A 5-per cent solution of iodide of potassium will render tuberculous sputum inactive in about twenty-four hours.

Iodide of potassium has a strong absorbing effect when given internally, especially on all pathological accumulations of cells. In connection with protoplasm, carbonic acid, and water the iodine will become free and combine with the cells in the pathological product, which will decrease their vital power and accelerate their absorption. It still remains to be explained in what that specific effect consists, which the iodine salts has on the actinomyces fungus. Several prominent authorities have investigated the subject, but all have given a different explanation. Nocard succeeded in cultivating actinomyces in gelatine containing 1 per cent of iodide of potassium, but this proves nothing, as the salt in this case will remain unchanged, and in that form has not even a slight antiseptic power. It is not necessary, however, that the iodine should have a specific influence on the fungus to produce that remarkable effect, which the drug evidently exercises on all actinomycotic new formations. This effect may simply be attributed to the strong absorbing power which iodide of potassium exercises on all pathological neoplasms and waste products. The colonies of actinomyces, when living and possessed with regenerative power, are always imbedded in a small amount of liquified tissue surrounded by a wide zone of inflammation. When an actinomycoma consists exclusively of granulosomatous tissue and connective tissue, the fungus is dead, or at least dying (Bostroem).

It will therefore be understood that the liquified tissue surrounding the parasite under the influence of the administered iodide of potassium will be absorbed, the soft granulosomatous tissue when partly deprived of the necessary pabulum by absorption will undergo a degenerative met-

amorphosis, and the round cells be converted into spindle cells, and the whole actinomycoma in this way will be turned into an inert mass of fibrous tissue, inclosing the dead calcified actinomyces tufts.

The yellow pus-like substance in which the living actinomyces is always imbedded is not true pus, though it has that appearance, but is merely the product of a degenerative metamorphosis (necrobiosis). True pus must contain pus corpuscles and specific pus-producing micro-organisms (pyogenic cocci and bacilli) (Bostroem).

Where iodide of potassium is administered in medium doses for any length of time it will affect not only the diseased parts, but the liberated iodine will combine with the normal cells in the body and produce a series of symptoms called iodism. This consists of a general emaciation, shrinking of the fat, atrophy of lymph glands, and of mammary glands, in connection with a chronic catarrh of nose and conjunctiva, and desquamation of the epidermis. When given in over doses, it will produce a catarrh of the stomach and intestines, and even cause hemorrhages. The manure will get dry and hard and coated with thick mucous, or eventually with blood. All these inconveniences, however, are easily avoided when the medicine is given in proper doses, care being taken that the animal gets plenty of nutritious and easily digestible food. It is not, however, advisable to administer iodide of potassium to milch cows, as it will reduce the milk secretion considerably or stop it altogether. Furthermore a great part of the drug is excreted through the milk, making it unfit for any use. When administered internally the drug permeates all the tissues in the body, even the muscles and bones, but it is, however, rapidly excreted again, especially through the urine and milk.

In treating actinomycosis in cattle with iodide of potassium the dose should never exceed one gram ($\frac{1}{4}$ dram) for every hundred pounds live weight, the proper dose being from 8 to 12 grams (2 to 3 drams) according to the size of the animal and the extent of the lesion. This dose may be given from five to six days, when the animal will show slight symptoms of iodism, viz: discharge of thick mucus from the nose and excretion of tears. The manure will become rather dry, but that is easily repaired by giving a dose of glauber salts and some bran mash. This will restore the appetite, and two days after the last dose was given the animal will be ready for another week's treatment, and so on until a cure is effected. If these precautions are taken, no ill effect will result from the treatment, and if properly fed the animal will gain in condition uninfluenced by the medicine. There is, however, a great difference as to the individual effect of the medicine on animals, but any farmer who takes an interest in seeing his stock doing well will easily perceive when it is time for him to stop and give the animal rest for two or three days.

The medicine is best administered dissolved in water and given by means of a slender, long-necked bottle, for example, a common Rhine-

wine bottle. One dose of medicine is dissolved in about a pint of water, the steer is seized by the nose to hold up the head, and the contents of the bottle is emptied into the mouth without fixing or securing the tongue in any way.

Where a man has several head of lumpy-jawed cattle to treat, they may not be of the same size and therefore not require the same dose of medicine. As the farmer or breeder is not usually in possession of a pair of scales sufficiently fine to weigh off such small doses as required, the most convenient way is to have the medicine, which is easily dissolved, prepared in a concentrated solution of the strength 1 to 2 (2 drams of the solution to contain 1 dram of iodide of potassium). The drug must be dissolved in distilled or rain water, as otherwise a precipitate will form from the salts present in common water. With such a concentrated solution and a measuring glass, it is easy to measure out the exact dose for every animal and pour it into the wine-bottle, half filled with common water.

EFFECT OF IODIDE OF POTASSIUM ON THE DIFFERENT ACTINOMYCOTIC NEW FORMATIONS AND THEIR TISSUES.

To give a detailed description of the various forms under which actinomycosis appears in cattle is not necessary here, as there is an abundance of literature on this subject. It shall only be mentioned that, from a therapeutic standpoint, we may divide them all into two classes: (a) those where the bones are involved and (b) those where only the soft tissue has become affected.

Of the 150 head experimented on, about sixty had lesions where the bone was affected. These may again be divided into two classes: first, where the lesion is located on the lower jaw, which is by far the most common, and, second, those where the facial bones and upper maxilla have become affected. In both cases, the lesion has been produced by an invasion of the germ, by means of a spikelet of barley or some other stiff vegetable particle, on which the germ has vegetated in nature. No other satisfactory explanation of the infection has been given so far, whether the invasion occurred through a decayed tooth or through some abrasion in the mucous membrane in the mouth, on the tongue, or in the pharynx. Bostroem has examined thirty-two cases of actinomycosis in the jaw bones, minutely, and in every case he found some vegetable particle located in the socket of the decayed molar, or in the gums, or even as deep as in the center of the swollen rarefied bone. Where the tongue is affected these foreign bodies may be found in almost every one of the nodules, and a microscopical examination will show them to be closely covered with actinomycetes. In five cases of actinomycosis in human beings, this authority has traced the infection back to the same origin, and thereupon advises people who may have that habit not to chew a piece of straw or to put grain, especially those kinds which are armed with a spikelet, in their mouths, as he

feels satisfied that this is the only way in which an infection can take place.

Where the lesion has only affected the soft tissues, the most common appearance is in form of a hard, round or egg-shaped tumor, lying loose in the connecting tissue under the skin, usually in the submaxillary, sublaryngeal, or parotid region. The tumor may vary in size and character, ranging from a walnut to a child's head and from being hard and solid to soft and fluctuating. In almost all cases, bony or soft, the skin that covers the tumor or swelling is more or less indurated and may on the large bony swellings obtain a thickness of 2 or 3 inches. These fibrous indurations, however, show a pronounced inclination to shrink where iodide of potassium has been administered for some time, and will, in most of the cases, disappear altogether, leaving the skin in its natural condition.

The first step toward a medical treatment of actinomycosis was when M. Thomassen, of Utrecht, in 1885, announced that he had successfully treated actinomycosis in the tongue of cattle by giving iodide of potassium internally and applying tincture of iodide to the ulcers on the tongue, which he first scraped. Since then this experiment has been repeated all over Europe by many different authorities and practitioners, with similar success. This lesion, however, is very seldom seen in this country, but seems to be rather common in Germany and certain parts of England. Of all the cattle in this experiment, not one had actinomycosis in the tongue, and the inspectors in the stock-yards have only seen it two or three times. The reason for this may be that actinomycosis in the tongue has a comparatively acute progress, and that an animal so affected rapidly loses in flesh, if medical treatment is not adopted. Now we know, however, that we can always master a case like this, even if the tongue is swollen to such a size that it protrudes from the mouth and is as hard as a board. Give 10 grams ($2\frac{1}{2}$ drams) of iodide of potassium a day, in the above-described way, care being taken to give the animal time to swallow the medicine, as deglutition is impaired considerably by the hard and swollen condition of the tongue. Feed the animal gruel and other fluid food, with a bottle if necessary. In ten to twenty days the tongue will regain its natural size and condition and the animal be enabled to eat hay.

Though none of the cattle in this experiment had the lesion in the tongue, several of them had it in the mucous membrane in the mouth, especially on the inside of the lips, but not to any great extent. It appears as small, flat tumor-formations, the size of a dime to that of a fifty-cent piece, of a reddish-gray color and only protruding a little over the surrounding parts. They will shrink and disappear completely in about two weeks when medicine is administered regularly.

When a medium dose of iodide of potassium has been administered from three days to a week, symptoms of iodism will appear, and at the end of two to three weeks a desquamation of the epidermis will take

place, especially on the neck, shoulders, and rump. But there are many exceptions. Some animals will show only a slight catarrh of the nose and none of the conjunctiva, while the desquamation will not take place before a month or six weeks or may not occur at all. Several of the steers experimented upon showed under the whole treatment not a single epidermic scale on their body, even if the dose of medicine was increased up to 15 grams a day. They would get a catarrh of the intestines, with constipation, but show no external symptoms of iodism. Such an insusceptibility of the constitution usually extends to the actinomycotic lesions, which would remain almost unaffected or only improve slightly. There are, however, also exceptions here, as one steer with a large tumor in the sublaryngeal space was almost completely cured without showing any epidermic desquamations.

INDIVIDUALS WHICH SHOW THE MOST PRONOUNCED SYMPTOMS OF
IODISM WILL IMPROVE THE FASTEST.

The effect of the medicine is rarely alike in two individuals, even if they are affected exactly the same way and to the same extent. The hard fibrous tumors lying loose in the connective tissue under the skin will require a treatment of from three to six weeks with proper intervals, according to their size. But in many cases a tumor the size of a child's head will shrink and disappear faster than a similar one located on the same place in an animal of the size and condition, but with the tumor only as large as a goose egg; the former will show a pronounced iodism, while the latter will show little or none at all.

When one of those loose fibrous tumors become fluctuating and is left alone, it will break open after a while and a comparatively small amount of pus will be evacuated. The pus cavity will rapidly fill up with the soft granulomatous tissue characteristic of actinomycosis, and when it is full it will grow out of the opening like a mushroom and form a granuloma, which will increase in size very fast as long as the supply of nutrition is abundant, after which the surface will begin to ulcerate.

If the treatment is commenced at this time, say with a daily dose of 10 grams of iodide of potassium, the rule is that the ulcerating surface of the granuloma will dry up and the granuloma itself will gradually shrink, apparently as if it were drawn in through the same hole it had grown out of. Then the fibrous parts of the tumor will commence contracting until the whole tumor has disappeared, leaving a small white cicatrix where the granuloma was. But here there are also exceptions. In some cases the granuloma may remain unaffected, while the fibrous parts begin to shrink first, and after a while the granuloma will become dry, shrinking slowly, but not disappearing completely, although the actinomyces are killed or rendered ineffective by the treatment.

When the disease affects the bony parts, the periosteum will become covered with thick layers of connective tissue inclosing centers of soft granulomatous tissue, and when it penetrates into the internal parts

the bone will increase in bulk in two different ways, either by a rarefying granulating osteitis or by an ossifying periostitis. The invading germ will cause an irritation, which will be followed by a formation of granulatous tissue in the cancelli of the spongiosa and in the Haversian canals. The bony plates of the former and the walls of the latter will be destroyed and replaced by large pockets or alveoli filled with soft granulatous tissue and with a creamy, viscid pus-like mass, containing numerous actinomyces.

The proliferating granulatous mass will finally penetrate the surface of the bone and infiltrate the covering tissues, and at last break through the skin, which will become thick and indurated and form a bulky fibrous wall around the fast-growing granuloma. The picture here described is that frequently seen on the lower maxilla. These tumefactions may attain enormous dimensions, and even reach the size of a half-peck measure, with granulomas 6 to 8 inches in diameter. Several specimens of this kind were included in the experiment, though such extreme cases practically never will be submitted to treatment.

Nevertheless, the effect of the medicine by far exceeded the expectations. With a few exceptions, they all showed wonderful improvement. Under the effect of a 12 to 15-gram daily dose, those large fetid ulcerating granulomas would dry up and shrink, most of them disappearing altogether, only leaving a white contracted cicatrix, while the fibrous parts of the tumefaction would become thinner every day and finally leave the swollen bone directly covered by the muscles and the skin. The post-mortem examination of these bony tumors revealed similar improvements. An incision through them showed the internal parts to be spongy, but the alveoli and pockets only contained very little granulatous tissue, and this was not soft, but of a more elastic and dense character, and only contained calcified actinomyces. In many of them no pus was found at all, while others contained small quantities. This remarkable improvement was seen in all those cases where the iodide of potassium had caused a well-pronounced iodism, while in those cases where the medicine had a less pronounced effect the improvement was equally small and quantities of pus and soft tissue could be found in the alveoli. Similar to the loose-lying tumors, the medicine may in these cases have a stronger effect on either the granuloma or the fibrous parts of the tumefaction. The first is the most common, but in a smaller number of cases the medicine takes effect exclusively on the fibrous parts, making them shrink so rapidly that the thick fibrous wall surrounding the granuloma contracts to such an extent that the whole granuloma is expelled, partly by force and partly on account of obstructed blood circulation.

There is no doubt that these results, obtained by a treatment which in no case lasted more than seven weeks and as an average not exceeding five weeks, permit us to say that in iodide of potassium we have found a valuable remedy in treating actinomycosis.

It now remains to decide which cases will prove of financial value for the farmer and breeder to treat, and this partly depends upon the facility with which the administration of the medicine can be performed. The amount of medicine used in a single case ought never to exceed 1 pound, equal to an expense of \$3. We suppose any steer will be worth that much. If the affected animals are being kept in a stable, as, for instance, in distilleries, the trouble about giving the medicine amounts to nothing. But where the animals are running loose in a pasture and there is no convenient place to tie them up it is no easy matter to catch them and secure them every day while the medicine is given. On ranges and similar places, where several hundred head of cattle are kept, the easiest way is to keep the affected cattle in a large pen, in the one side of which is built a narrow chute, into which the cattle can be driven one by one and treated. Such a chute may be constructed out of a few solid boards without much expense. To administer the medicine in the drinking water is not advisable, as it is then rather difficult to control the right dose. The cattle will not drink a pailful of water with a dose of iodide of potassium, except when they are very thirsty.

As to the different lesions, it has already been said that when the tumor is not connected with the bony tissue, but is lying loose in the connective tissue under the skin, a favorable result may be expected in from two to five weeks, according to the size of the tumor and to the susceptibility of the individual toward the effect of the medicine.

It is not necessary to continue the treatment until the tumor has disappeared completely, but it may be stopped when it has shrunk to about one-third of its original size, and the remainder will usually disappear without further treatment. When a small tumor about the size of a hen's egg is located on the cheek or on the outside of the lower jaw, it is usually very hard and can only be moved very little, so it is easily mistaken for a bony tumor. A careful examination, however, will soon prove that it is not bony, and when treatment is commenced it will rapidly decrease in size.

When the bone is affected, treatment is only advisable when the swelling does not exceed a goose egg in size on the lower jaw or a walnut on the upper jaw, and has not penetrated the skin; but in any case the medicine will avert a further development of the disease if the animal is at all susceptible to its effect.

Two cases as above described, and with a small bony tumor on the lower maxilla, were killed on October 29, 1892, after a six weeks' treatment. The bony swellings were then almost solid, contained no large cavities and no traces of pus or soft tissue. In the center of them was a bunch of white connective tissue, and from this extended a cord of the same material to the socket of the first molar. This was an obliterated fistula. The molar was not decayed and was firmly embedded in the socket. This is a clear proof that actinomycotic lesions in the bony tissue can be successfully treated when they are taken in time.

POST-MORTEM EXAMINATION.

November 29, 1892, two lots of cattle experimented upon were killed. Each lot contained forty head, the one consisting of cattle that were supposed to be completely cured, while the second lot included all the old chronic cases, where a successful result could not be expected in the time limited for the experiment.

In the special report of each animal the description of the post-mortem examination will be found. This is necessarily very brief.

The forty cattle which were supposed to be cured proved to be so with the exception of two, which had small actinomycotic tumors in the lung containing living actinomyces. In nine other cases traces of the disease were found at the place where the tumors had been located, but these traces were so insignificant, ranging in size from a pin's head to a bean, that they did not amount to anything.

The first lot were all in good condition, some of them very fat, and the greater part of the second lot also were in a very satisfactory condition, only a few of them being really poor. A noteworthy fact is that only two out of each lot had actinomycotic lesions in the internal organs, all cases in the lungs. This would hardly have been the case if the cattle had not been treated. In some cases a few small nodules, in size from a millet seed to a pea, containing a cheesy, greenish detritus mass, were found in the wall of the small intestines, but a microscopical examination of these lesions gave negative results with regard to actinomycosis. The final result of the investigation was that out of the first lot thirty-eight were passed as fit for human food, while the two cases affected with actinomycosis in the lung were condemned. Of the other forty only five were passed and thirty-five condemned, though many of them were big fat steers with the lesion located on the jaws and no internal lesions of any kind. The tumors on the greater part of these did not contain any pus, and the granulomatous tissue had undergone a fibrous metamorphosis, and subsequently did not contain any actinomyces possessed with regenerative power.

December 2 twenty more head of cattle were killed. These had been stabled in the same barn as the rest and had been treated from three to six weeks each with proper intervals. They were all used to the distillery slops before the treatment began and continued to grow in flesh while they were treated. They were all pronounced cases, but only the soft tissues were involved. The lesions were about the same as those in the first lot, hard, fibrous tumors, the size from a goose egg to a child's head, located in the loose connective tissue under the skin in the submaxillary or sublingual space. They all recovered completely and at the post-mortem examination no traces of the disease except in two cases, a hard, fibrous induration in the skin, tumors had been. They were all passed as fit for human food. As regards the treatment and the post-mortem examination of these cases are given in the form of an appendix to

APPENDIX.

No. 533796.

Dark-red hornless steer; received August 22.

In the submaxillary space is located an oblong tumor extending from the chin to the neck, with a dependence of 4 inches. The tumor was of a fibrous condition, but not very hard. In the parotid region on the right side is located a hard, fibrous tumor the size of a goose egg.

Treatment was commenced August 24 with a daily dose of 12 grams and was continued until September 13, at which time the swelling underneath had disappeared and the tumor in the parotid region had shrunk considerably. October 20 the tumor in the parotid region was swelled a little and fluctuating. It was opened with a knife, and a small amount of pus discharged. Medicine was again administered for two weeks, and by November 12 the steer was regarded as cured.

Post-mortem, November 29.—Skin under submaxillary space indurated. Fibrous scar in parotid region. No traces of actinomycosis. No internal lesions. Carcass passed as sound.

No. 45982.

Roan steer, white sides, hornless; received September 5.

In sublingual space on left side is located a hard fibrous tumor the size of a double clinched fist, extending up in parotid region toward the ear. The lower part of the tumor is lying loose under the skin, but the part in the parotid region is in close connection with it.

Treatment was commenced September 7 with a daily dose of 12 grams and was continued until October 12, by which time the tumor had shrunk to the size of a walnut and only left a fibrous induration in the skin in parotid region. The steer was considered cured about October 15.

Post-mortem, November 29.—No traces of the tumor left. No internal lesions. Carcass passed as sound.

No. 39976.

Dark-red steer, white face and rump, horns; received August 28.

In sublingual space in left side is located a fibrous tumor the size of a child's head. The tumor is not quite as hard as is generally the case, but is closely connected with the skin.

Treatment was commenced August 30, with a daily dose of 10 grams, and was continued until October 1. Two weeks later no traces of the tumor could be felt, but in the skin was still left a thick fibrous induration. Medicine was again administered until November 1, by which time the skin had almost regained its natural condition. About November 10 the steer was considered cured.

Post-mortem, November 29.—Slight thickening of the skin in sublingual space. No traces of the tumor left. No internal lesions. Carcass passed as sound.

No. 39963.

White roan steer, hornless; received August 28.

In parotid region on the left side is located a tumor the size of a large goose egg, which at the lower end extends into a hard fibrous swelling, filling the intermaxillary and sublingual space, depending about 5 inches below the throat.

The treatment was commenced August 30, with a daily dose of 10 grams. The medicine had a good effect, causing a strong catarrh of nose, mouth, and conjunctiva and made the tumor and swelling shrink rapidly. After four weeks the treatment was stopped and the steer regarded as cured about October 10.

Post-mortem, November 29.—The skin that covered the tumor a little indurated. No traces of the disease left here nor internally. Carcass passed as sound.

No. 499857.

Red steer, white star, rudiments of horns; received August 16.

In the sublingual space on the right side is located a tumor the size of a clinched fist. The tumor is hard and fibrous with a smooth surface and lying loose under the skin.

The treatment was commenced August 18 and continued for three weeks with daily dose of 10 grams. The medicine had a strong effect on the steer, and already, September 12, the tumor had completely disappeared. In spite of a well-defined iodism the steer did not lose flesh under the treatment, but his condition improved considerably.

Post-mortem, November 29.—No traces of the tumor left. No internal lesions. Carcass passed as sound.

No. 545801.

Speckled dehorned steer, white face; received August 22.

In sublingual space on right side is seen a tumor the size of a clinched fist located in loose connective tissue under the skin. The tumor is hard and fibrous with no evidence of having been opened.

Treatment was commenced August 24; daily dose, 10 grams. The tumor began to shrink from the fourth day, and in less than three weeks it had gone down to the size of a walnut. The steer was then covered all over with epidermic scales, and was considered cured about October 7.

Post-mortem, November 29.—No traces of the disease were found either on neck or internally. Carcass was passed as sound.

No. 545523.

Brindle steer, hornless; received August 16.

On the outside of the right cheek, near the lower edge of the inferior maxilla, is located a hard fibrous tumor the size of a goose egg. The tumor is situated in the short connective tissue under the skin. In submaxillary space there is a similar tumor the size of a double clinched fist.

Treatment was commenced August 18, with a daily dose of 10 grams, and was continued until September 12. The steer showed a pronounced iodism, and the tumors shrunk rapidly. When the treatment was stopped the tumor in submaxillary space had disappeared, and the other one had shrunk to the size of a walnut. October 1 the steer was considered cured.

Post-mortem, November 29.—No traces of the tumors left, except a slight induration in the skin. No internal lesions. Carcass passed as sound.

No. 534024.

Brindle steer, horns; received August 22.

On left cheek outside second molar is located a hard fibrous tumor the size of a walnut. It is situated in the short connective tissue under the skin and can only be moved very little. In the intermaxillary space there are two tumors, the foremost one a little larger than the above mentioned, and the other one about the size of a double clinched fist.

The treatment was commenced August 24 with a daily dose of 10 grams. Two weeks later the two smaller tumors had disappeared, and by September 20, when the treatment was stopped, there was only a small part of the largest one left.

Post-mortem, November 29.—In intermaxillary space was found a small fibrous induration the size of a robin's egg. The surrounding lymph glands were a little swollen, but sound. The carcass was passed as sound.

No. 545512.

Red dehorned steer, white triangular spot on left side; received August 16.

On the left cheek are located four hard fibrous tumors from the size of a walnut to a hen's egg. They form a line from the angle of the mouth toward the back edge of the jaw, the last one being located a little below the ear. They are very hard and can only be moved slightly. In sublaryngeal space on left side is located a tumor the size of a double clinched fist.

Treatment was commenced August 18 with a daily dose of 10 grams, and was continued until September 10, at which time the four tumors on the cheek had disappeared and the one on the throat had shrunk to the size of a hen's egg. September 25 the steer was regarded as cured.

Post-mortem, November 29.—One of the sublaryngeal lymph glands contained a small actinomycoma the size of a bean. No traces left of the tumors, excepting a small induration in the skin covering the throat. No internal lesions. Carcass passed as sound.

No. 39964.

Red spotted steer, white star; received August 28.

The right lower maxilla is swollen to the size of a goose egg, between the incisor and the first molar. The bony swelling is covered with a layer of fibrous tissue, which makes the swelling appear the size of a double clinched fist. In the submaxillary space are a couple of small soft swellings the size of walnuts.

Treatment was commenced September 1, with a daily dose of 12 grams and was continued until October 30, with proper intervals. By this time the swollen glands in the submaxillary space had regained their normal size and condition, while the tumor on the jaw had only shrunk very little, but had become considerably harder. Only on the lower part of it was left some of the fibrous covering. The bony swelling seemed to have increased a little in size, while the fibrous tissue was absorbed.

Post-mortem, November 29.—Small fibrous infarct in sublingual lymph gland. The bony swelling was spongy, but did not contain any pus cavities. It was covered by a thin layer of fibrous tissue, which on the lower side of the swelling inclosed a small soft granuloma. In the wall of the small intestines were located a few small round hard nodules.* One of the mesenteric glands was a little enlarged. By the microscopic examination no actinomycoses was found in any of these. No other internal lesions. Carcass passed as sound.

*These nodules, which are frequently mentioned in the post-mortem notes, have nothing to do with actinomycosis or lumpy-jaw. They are very common in healthy cattle and are caused by animal parasites.—D. E. S.

No. 545742.

Brown steer, horns; received August 22.

On the right cheek is located a hard fibrous tumor the size of a hen's egg outside the third molar. In the submaxillary space there is another tumor the size of a coconut. The lower part of this tumor was fluctuating, and consequently was opened with a knife. It only contained about one ounce of pus. The rest of the tumor was hard and fibrous.

Treatment was commenced August 24, with a daily dose of 10 grams, and was continued until September 1, with proper intervals. The medicine did not have any strong effect, the tumors only shrinking slowly. October 7 there was still left a tumor the size of a goose egg under the jaw, while there only remained a small fibrous bunch from the tumor on the cheek. Medicine was then again administered for three weeks, and by November 12 the steer was considered cured.

Post-mortem, November 29.—No traces of the disease left except a small fibrous cicatrix on the cheek and a fibrous induration in the skin in submaxillary space. No internal lesions. Carcass passed as sound.

No. 545559.

Light brown Montana-Texas steer; received August 16.

In right parotid region is located a hard fibrous tumor the size of a goose egg. In the submaxillary space on right side there is a similar tumor the size of a double clinched fist lying loose in the connective tissue under the skin.

Treatment was commenced August 18 with a daily dose of 10 grams, and was continued until October 1, with proper intervals. The steer showed no symptoms of iodism, the tumors shrinking only slowly, especially the one in the parotid region. From November 1 to November 15 medicine was again administered, and soon afterwards both tumors had disappeared, the upper one leaving a small fibrous induration on the angle of the lower maxilla.

Post-mortem, November 29.—No traces of the tumors left. No internal lesions. Carcass passed as sound.

No. 540519.

Black steer, dehorned; received August 16.

On the right side of the face, between eye and nose, is located a bony swelling the size of a hen's egg, with a scar on the top, indicating that it has been suppurating. On the right cheek, outside the third molar, is located a hard fibrous tumor, the size of a goose egg, lying loose in the connective tissue under the skin. In sublingual space there is located another tumor the size of a double clinched fist.

The treatment commenced August 18, with a daily dose of 10 grams of iodide of potassium, and was kept up for four weeks, with the exception of one or two days a week. The tumor on the cheek and under the throat soon commenced to shrink, while the bony one broke open and discharged a little pus, after which it healed up again. At the end of the fourth week the two fibrous tumors had gone down to about one-third the original size, and the treatment was stopped. Three weeks later they had almost disappeared, while the bony one was exactly the same size as before the treatment. From October 15 to October 24 medicine was again administered daily, but the bony tumor remained unchanged.

Post-mortem, November 29.—The bony swelling on right upper maxilla consisted of solid bone, and contained neither pus nor soft tissue. No traces were left of the other tumors. No internal lesions. Carcass passed as sound.

No. 545797.

Red hornless bull; received August 22.

On the right lower maxilla, outside the first molar, is located a hard fibrous bony tumor the size of a clinched fist. In submaxillary space on left side is seen another tumor, the size of a child's head, lying loose in the connective tissue under the skin. The skin covering the lower part of the tumor is fibrous indurated.

Treatment was commenced August 24, with a daily dose of 10 grams of iodide of potassium, and was continued until October 15, with proper intervals. The tumor under the throat had then gone down to the size of a goose egg, while the fibrous parts of the bony swelling on the lower jaw had disappeared, leaving it bony, hard, and the size of a hen's egg. November 15 the tumor under the throat had disappeared completely, only leaving a fibrous thickening in the skin.

Post-mortem, November 29.—Fibrous induration in skin under throat. An incision through the bony swelling shows this hard and solid, with no cavities, but with a small fibrous mass in the center, from which the obliterated remainders of a fistula goes up to the socket of the first molar. No lesions internally. The carcass was passed as sound.

No. 59141.

Dark red steer, hornless, roan face; received August 28.

The entire intermaxillary and sublingual space is occupied by an oblong and rather soft tumor. The skin covering the tumefaction is indurated, and closely attached to the underlying tissue. The tumor depends about 5 inches below the lower edge of the under jaw.

Treatment was commenced about August 30, with a daily dose of 12 grams, and was continued until October 5, with proper intervals. The steer showed a pronounced iodism, and the tumor shrunk rapidly, but for a long while the skin remained very thick and indurated. This, however, disappeared slowly after the treatment was stopped. About October 20 the steer was regarded as cured.

Post-mortem, November 29.—In intermaxillary space is located a flat fibrous induration, about 2 inches long and 1 inch thick, inclosing a small abscess the size of a bean, containing thin yellow pus. No actinomyces was found by microscopical examination. No internal lesions. Carcass passed as sound.

No. 45983.

Red steer, hornless, white star; received September 5.

On the left side of the face, about 3 inches below the eye, is located a hard bony swelling the size of a clinched fist.

Treatment was commenced September 7 with a daily dose of 12 grams, and was continued until November 1. The steer showed a pronounced iodism, but the size of the tumor remained almost unchanged.

Post-mortem, November 29.—The thin fibrous covering on the bony swelling contained a few small pockets the size of peas. The contents of these pockets had originally been soft granulomatous tissue, but consisted now of a fibrous homogeneous mass of a light yellow color, but still bearing resemblance in structure to the former tissue, which during the treatment had undergone a fibrous metamorphosis. On the cut surface these centers protruded a little over the indurated tissue in which they were embedded, showing that they had been under a pressure. The internal parts of the bony swelling were spongy, but contained neither soft tissue nor pus. The lymph glands on the head were sound. No internal lesion. Carcass was passed as sound.

No. 40001.

Roan heifer, horns; received August 22.

The left cheek, from the eye down to the lower edge of the jaw, is covered by a hard fibrous tumor, which is fluctuating on the most prominent part. It was opened with a knife and a few ounces of good yellow pus evacuated.

Treatment was commenced August 24, with a daily dose of 10 grams, and was continued until October 10, with proper intervals. The heifer showed only slight symptoms of iodism, and the tumor only shrunk slowly. When the treatment was stopped another abscess formed in the same place, which was also opened. From October 20 to November 10 medicine was again administered, and the tumor was considerably reduced in size.

Post-mortem, November 29.—On the right cheek is located a fibrous induration about 1 inch thick and 3 inches in diameter, containing slight traces of soft tissue centers. The lymph glands on the head were sound. No internal lesions. Carcass passed as sound.

No. 39974.

Spotted roan steer, horns; received August 28.

On the right lower maxilla, below the first molar, is located a fibrous bony swelling the size of a clinched fist. In the intermaxillary space there is a hard fibrous tumor about the same size, lying loose in the connective tissue under the skin.

Treatment was commenced August 30, with a daily dose of 12 grams, and was continued until October 20, with proper intervals. The steer showed a pronounced iodism, and the tumor in the intermaxillary space disappeared completely, while the swelling on the lower jaw was reduced to the size of a goose egg by the shrinking of the fibrous covering.

Post-mortem, November 29.—No traces of the fibrous tumor left, except a small induration in the skin. Surrounding lymph glands sound. An incision through the bony swelling showed this to be solid bone throughout, with the exception of a small bunch of white connective tissue in the center, from which a cord of the same material leads to the socket of the second molar. No internal lesions. Carcass passed as sound.

No. 45594.

Dark red steer, horns; received September 12.

In the loose connective tissue in the submaxillary space is located a tumor the size of a double clinched fist.

Treatment was commenced September 14, with a daily dose of 12 grams, and was continued until October 10, by which time the tumor had shrunk to the size of a walnut. About October 25 the steer was considered cured.

Post-mortem, November 29.—Small, fibrous induration in the skin in submaxillary space. No traces of the tumor left. No internal lesions. Carcass passed as sound.

No. 25873.

Dark red steer, hornless, white star and white spot on left hip; received September 12.

The intermaxillary space is completely filled from the chin to the neck with a fibrous swelling, which, on the left side, extends up into the parotid region toward the ear. The swelling is rather soft, and is closely connected with the indurated skin.

The treatment was commenced September 14, with a daily dose of 10 grams, and was continued until October 25, by which time the swelling had disappeared, but

the skin was still hard and very thick. This, however, improved rapidly, and by November 12 the steer was considered cured.

Post-mortem, November 29.—No traces of the swelling left. No internal lesions. Carcass passed as sound.

No. 546042.

Blue roan steer, hornless; received August 22.

In the sublaryngeal space on the left side is located a hard fibrous tumor the size of a cocoanut, lying loose in the connective tissue under the skin.

Treatment was commenced August 24, with a daily dose of 12 grams, and was continued until October 7, with proper intervals. The steer showed no symptoms of iodism whatever, and when treatment was stopped the tumor had only shrunk to about one-half its original size. Medicine was again administered from October 20 to October 31, during which time the tumor improved rapidly. About November 12 the tumor had disappeared, only leaving a thick induration in the skin.

Post-mortem, November 29.—No traces of the tumor left. No internal lesions. Carcass passed as sound.

No. 48040.

Red steer, hornless; received August 30 from Kansas City.

In the sublaryngeal space on left side is located a hard fibrous tumor the size of a child's head, lying loose in the connective tissue under the skin. In right parotid region there is a hard, flat, fibrous swelling, which is closely connected with the skin.

Treatment was commenced September 1, with a daily dose of 12 grams, and was continued until October 1, with proper intervals. By this time the tumor under the throat had shrunk to the size of a hen's egg, while the swelling in the parotid region had become considerably reduced. About October 20 the steer was regarded as cured.

Post-mortem, November 29.—No traces of the tumors left, except a fibrous thickening in the skin in the parotid region. No internal lesions. Carcass passed as sound.

No. 39985.

Red steer, white face, white rump and legs; received August 28.

In the loose connective tissue in the submaxillary space are located three hard fibrous tumors the size of goose eggs. The skin covering them is considerably indurated.

Treatment was commenced August 30, with a daily dose of 12 grams, and was continued until September 20, by which time the tumors had shrunk to the size of a walnut, and the induration in the skin had become thinner. October 18, the steer was considered cured.

Post-mortem, November 29.—Slight induration of skin in submaxillary space. No traces of the tumors left. No internal lesions. Carcass passed as sound.

No. 45953.

Red steer, white star, hornless; received September 5.

In left parotid region is located a hard fibrous tumor the size of a goose egg. In the sublaryngeal space on left side there is a similar one the size of a double clinched fist. The first one is closely connected with the underlying tissue, but the other one is located in the loose connective tissue under the skin.

Treatment was commenced September 7, with a daily dose of 12 grams, and was continued until October 7, with proper intervals. By this time both tumors had shrunk considerably, and about October 28 the steer was regarded as cured, though there was still left a small deeply situated induration in the intermaxillary space.

Post-mortem, November 29.—In the intermaxillary space is located a small, flat, fibrous induration the size of a walnut, inclosing three granulomas the size of beans. The skin in left parotid region a little indurated. No internal lesions. Carcass passed as sound.

No. 22485.

Red steer, white face, horns; received August 30 from Kansas City.

In the submaxillary space are located three hard fibrous tumors the size of goose eggs, and in the right parotid region there are two similar tumors, the lower one the same size and the upper one the size of a hen's egg. The skin covering the tumors in submaxillary space is hard and thickened.

Treatment was commenced September 1, with a daily dose of 12 grams, and continued until October 15 with proper intervals. The steer only showed slight symptoms of iodism, and the tumors shrunk rather slowly. When treatment was stopped none of the tumors were larger than a walnut. About November 10 the steer was considered cured.

Post-mortem, November 29.—In the intermaxillary space were found two small fibrous indurations, each containing a couple of small soft granulomas the size of a pea. No internal lesions. Carcass passed as sound.

No. 39994.

Red steer, horns; received August 28.

The intermaxillary space is completely filled, from the chin to the neck, with a fibrous swelling of rather soft condition. The skin is closely connected with the underlying swelling.

Treatment was commenced September 1, with a daily dose of 12 grams, and was continued until September 30, by which time the swelling had shrunk considerably. October 12 the steer was regarded as cured.

Post-mortem, November 29.—The skin that covered the swelling is fibrous indurated. No traces of actinomyces to be found. No internal lesions. Carcass passed as sound.

No. 44531.

Red steer, horns; received September 12.

In sublingual region on left side is located a hard, fibrous tumor the size of a double-clinched fist, lying loose in the connective tissue under the skin.

Treatment was commenced October 14, with a daily dose of 12 grams, and was continued until October 15, by which time the tumor had shrunk to the size of a hen's egg. November 10, the steer was considered cured.

Post-mortem, November 29.—One of the submaxillary lymph glands was swollen to the size of a walnut, and contained an abscess the size of a bean, filled with pus containing actinomyces. Sublingual lymph gland in right side indurated. No internal lesions. Carcass passed as sound.

No. 25386.

Red steer, white star, roan spot on right side and left thigh, hornless; received September 12, 1892.

In the loose connective tissue in the submaxillary space is located a hard fibrous tumor the size of a child's head.

Treatment was commenced September 14, with a daily dose of 15 grams, and was continued until October 12, by which time the tumor had shrunk to the size of a hen's egg. October 25, the steer was regarded as cured.

Post-mortem, November 29.—No traces of the tumor left. No internal lesions. Carcass passed as sound.

No. 534041.

Dark red, Hereford-crossed steer, white on hips; received August 22.

In the left parotid region is located a hard, flat, fibrous swelling, which at the lower end extends into a tumor the size of a child's head, located in the sublaryngeal space. Two inches in front of this tumor, in the submaxillary space, there is another one the size of a goose egg.

Treatment was commenced September 24, with a daily dose of 12 grams, and continued until October 1. The steer showed no symptoms of iodism, and no desquamation of the epidermis appeared under the whole treatment. Nevertheless the tumors shrunk rapidly, especially the largest one in the sublaryngeal space. October 16, the steer was regarded as cured.

Post-mortem, November 29.—In one of the submaxillary lymph glands was located a granuloma the size of a bean. The skin in the parotid region a little indurated. No internal lesions. Carcass passed as sound.

No. 40002.

Black speckled heifer, hornless; received August 22.

In the loose connective tissue in the intermaxillary space is located a hard fibrous tumor the size of a double clinched fist.

Treatment was commenced August 25, with a daily dose of 10 grams, and was continued until September 20. By this time the tumor had almost disappeared, and by October 1 the steer was considered cured.

Post-mortem, November 29.—No traces of the tumor left. No internal lesions. Carcass passed as sound.

No. 131056.

Red steer, horns, white on left flank; received September 5.

In the sublaryngeal space on left side is located a hard fibrous tumor the size of a double clinched fist, lying loose in the connective tissue under the skin.

Treatment was commenced September 7, with a daily dose of 10 grams, and was continued until October 7, with proper intervals. By this time the tumor had shrunk to the size of a walnut. October 20 the steer was regarded as cured.

Post-mortem, November 29.—No trace of the tumor left. No internal lesions. Carcass passed as sound.

No. 25150.

Red steer, horns; received September 5.

In the sublaryngeal space on the right side is located a hard fibrous tumor the size of a cocoanut, lying loose in the connective tissue under the skin.

Treatment was commenced September 7, with a daily dose of 12 grams, and was continued October 1. The steer showed a pronounced iodism, and the tumor shrunk rapidly. October 15 the steer was considered cured.

Post-mortem, November 29.—No traces of the tumor left. No internal lesions. Carcass passed as sound.

No. 25162.

Red steer, white star, horns; received September 12.

In the sublaryngeal space on the left side is located a tumor the size of a child's head. On the lower end of it, the skin is in close connection with the tumor, and out through the skin extends a round soft granuloma, about 4 inches in diameter and 1 inch thick. The surface of the granuloma is uneven and covered with pus crusts.

Treatment was commenced September 14, with a daily dose of 14 grams, and was

continued until October 20. with proper intervals. The granuloma began to dry up right away, and in the third week it had shrunk to a level with the surrounding parts and was covered with epidermis. When the treatment was stopped the tumor had gone down to the size of a hen's egg, with a small white scar at the place where the granuloma was, surrounded by heavy wrinkles of skin. About November 12 the steer was regarded as cured.

Post-mortem, November 29.—Small fibrous thickening in the skin where the tumor was. No internal lesions. Carcass passed as sound.

No. 131035.

Red steer, horns, white star and spot on shoulder; received September 5.

In the sublingual space on the left side is located a fibrous tumor the size of a child's head. It is lying loose in the connective tissue under the skin.

Treatment commenced September 7, with a daily dose of 12 grams, and was continued until October 10, with proper intervals. By this time the tumor had sunk to the size of a goose egg, and the rest disappeared without further treatment. October 25 the steer was considered cured.

Post-mortem, November 29.—One of the submaxillary lymph glands showed a fibroid degeneration, having evidently contained an actinomycoma, which under the treatment had undergone a fibrous metamorphosis. No trace of the tumor was left except a fibrous induration in the skin. No internal lesions. Carcass passed as sound.

No. 25870.

Dark red steer, hornless; received September 12.

In the left parotid region is located an extensive, flat, hard, fibrous swelling, which below extends into a tumor filling the intermaxillary space.

Treatment was commenced September 14, with a daily dose of 15 grams, and was continued until October 15. By this time the tumor below had shrunk to about one-third its original size, while the swelling in the parotid region remained almost unchanged, though not quite as prominent as before. November 1 the treatment was commenced again, and the tumors now began to improve rapidly. November 10 treatment was discontinued, and shortly afterwards the steer was considered cured.

Post-mortem, November 29.—One of the sublingual lymph glands contained an abscess the size of a hazelnut, in which was found yellow pus with actinomyces. No internal lesions. Carcass passed as sound.

No. 39984.

Dark red, hornless steer; received August 28.

In the sublingual space on the right side is located a tumor the size of a child's head. It is lying loose in the connective tissue under the skin.

Treatment was commenced September 1 with a daily dose of 10 grams, and continued until October 10. The steer showed marked symptoms of iodism and the medicine had a good effect on the tumor. When the treatment was stopped there still remained a tumor the size of a hen's egg, covered by a rather extensive hard induration in the skin. November 1 the tumor had completely disappeared, and even the induration in the skin had grown thinner.

Post-mortem, November 29.—Fibrous thickening in skin under larynx. One of the sublingual lymph glands contained a very small actinomycoma the size of a large pin head. No internal lesions. Carcass passed as sound.

No. 48056.

Red steer, hornless, speckled body, white belly; received August 30, from Kansas City.

The intermaxillary space is completely filled with an oblong tumor, extending

from the chin to the neck, and depending about 3 inches below the lower edge of the jaw. The tumor is hard and fibrous and in close connection with the skin. On the inside of the upper lip are located two soft red actinomycomas about the size of a nickel.

Treatment was commenced September 1st, with a daily dose of 12 grams, and was continued until October 7, by which time there only remained a fibrous induration in the skin under the jaw. The actinomycomas inside the lip had disappeared during the third week of the treatment. The steer was considered cured about October 15.

Post-mortem, November 29.—No traces of the disease left under the jaw or in the mouth. No internal lesions. Carcass passed as sound.

No. 48037.

Red steer, hornless, received August 30, from Kansas City. On both cheeks outside the third molar is located a hard fibrous tumor the size of a hen's egg. They are situated in the short connective tissue under the skin, and as they are hard and can only be moved slightly, give the impression that they are bony. In the loose connective tissue in submaxillary space there is another tumor the size of a clinched fist.

The treatment was commenced September 1st with a daily dose of 12 grams, and was continued until October 1, at which time there was only a small trace left of the tumors. October 12 the steer was regarded as cured.

Post-mortem, November 29.—The sublingual lymph glands were a little swollen, but no traces of the tumors were left. No internal lesions. Carcass passed as sound.

No. 48,020.

Red steer, hornless, brockled face, white on shoulder and hip; received August 20 from Kansas City.

In right parotid region is located a hard, fibrous tumor the size of a goose egg, and another one, the size of a child's head, is seen in the loose connective tissue in the sublingual space.

Treatment was commenced September 1, with a daily dose of 12 grams iodide of potassium, and was continued until October 10. The steer showed very pronounced iodism, and the tumors shrunk fast. October 28 they had disappeared.

Post-mortem, November 29.—No traces of the disease left except a small callous in the skin where the tumors had been. No internal lesions. Carcass passed as sound.

No. 533950.

Red steer, white face, shoulder and rump; received August 22.

On the back edge of the right lower jaw is located a fluctuating tumor the size of a goose egg, and two hard fibrous tumors of the same size in submaxillary space.

Treatment was commenced August 24, with a daily dose of 10 grams. The abscess was opened with a knife, and a few ounces of thick yellow pus evacuated. The pus did not contain actinomyces. The treatment was continued until September 20. The tumors shrunk rapidly and had disappeared about October 2.

Post-mortem, November 29, 1892.—In the submaxillary space was left a small, fibrous induration containing two abscesses the size of beans. The contents of these was a thin yellow pus. The microscopic examination proved actinomyces to be present. Treatment was stopped a little too soon. Carcass passed as sound.

No. 25854.

Red hornless steer; received September 12.

In right parotid region is located a fibrous tumor the size of a goose egg, and

another the size of a child's head is seen in submaxillary space. Both are hard, round, and with a smooth surface lying loose under the skin.

Treatment was commenced September 14, with daily dose of 12 grams. Both tumors shrunk very fast, and one month later had gone down to one-third their original size. No more medicine was given and about November 12, the steer was considered cured.

Post-mortem, November 29.—Fibrous induration of skin underneath the throat. No traces of actino. In the liver there were two small abscesses the size of hazelnuts. Microscopic examination proved they were not caused by actinomycosis. The carcass was passed as sound.

No. 45943.

Brown hornless steer, white star; received September 5.

In left parotid region is located a hard fibrous tumor the size of a double clinched fist, and another one the same size in submaxillary space.

Treatment was commenced September 7 with a daily dose of 12 grams, and was continued until October 15. The tumors shrunk fast and by November 12 no trace of them was left, not even in the skin.

Post-mortem, November 29.—Neither on the head nor in the internal organs was any of the disease found. The carcass was passed as sound.

No. 39988.

Dark red steer, hornless, received August 28.

The right lower maxilla below the first molar is swollen to the size of a double clinched fist. It is bony, hard, but the covering skin is thick and indurated, and closely attached to the underlying tissue.

Treatment was commenced, August 30, with a daily dose of 12 grams, and was continued until October 20, with proper intervals. The steer showed a pronounced odism, and the tumor shrunk a little and became bony hard.

Post-mortem November 29.—In the indurated skin on the swelling was located a few small centers of soft tissues the size of peas. The internal tissue of the bone was rather solid, only a trifle spongy with no traces of the disease. The lymph glands on head were sound. No internal lesions. Carcass passed as sound.

No. 39992.

Black hornless steer, August 28, 1892.

Bony swelling of right lower maxilla, similar to above No. 39988. Treatment the same.

Post-mortem, November 29.—The internal parts of the swelling were spongy, and contained several centers of soft tissue the size of hazelnuts. No pus was found. Lymph glands sound. No internal lesions. Carcass was condemned.

No. 130915.

Red white-speckled steer; white star and horns; received August 30.

All the facial bones on the right side of the head are immensely swollen from the edge of the lower eyelid down to the nose. There is hardly any fibrous covering on the bony parts, except below, where the tumor gradually goes over on the lower maxilla. On the most prominent part of the swelling is an ulcer the size of the palm of a hand, located about 4 inches below the eye. The lachrymal duct is obliterated so that the tears run down over the tumor.

Treatment was commenced September 1st, with a daily dose of 15 grams and continued to October 25, with proper intervals. The medicine caused well-marked

symptoms of iodism, but the tumor remained almost unchanged, the fibrous swelling on the lower jaw shrinking a little. The ulcer dried up and left a small scar 1 by 2 inches. As no further improvement could be expected the treatment was stopped.

Post-mortem, November 29.—An incision through the bony swelling shows this completely filled with numerous cavities the size of peas, filled with pus and soft tissue, both containing actinomyces. No lesions in internal organs. Carcass condemned.

No. 545524.

Red dehorned steer, white star, white on left fore knee, side, and hip; received August 16, 1892.

The left lower maxilla is immensely swollen from the mouth and backwards. On the lower part of the swelling, which occupies the whole intermaxillary space, and has a dependence of 5 to 6 inches below the original edge of the jaw, is located an ulcerating granuloma about 7 inches in diameter, protruding about 3 inches over the surroundings. The deeper parts of the swelling are hard like bone, covered with a thick layer of fibrous tissue, which around the granuloma forms a heavy swollen wall 2 to 3 inches thick. Upwards the fibrous part of the tumor extends over the upper jaw and the parotid region, gradually growing thinner up against the eye and ear. The skin covering the tumor is closely connected with it all over. The surface of the granuloma is uneven, covered with crusts, and small drops of pus constantly ooze out at many different places. The base of the granuloma is a little smaller than the circumference of it. A 2-inch deep fissure separates the edges of the granuloma from the epidermis covered parts. The steer is constantly grinding his teeth and slobbering from the mouth. Condition rather poor.

The treatment was commenced August 18 with a daily dose of 12 grams, and was continued until October 25, with proper intervals. The tumor apparently did not shrink much, though the fibrous parts of it, especially on the upper jaw, were reduced considerably. The granuloma dried up, but shrunk only very slowly. By November 12 there was only a scar about 5 inches in diameter left at the place where the base of the granuloma was, and the fibrous wall which surrounded it had also grown considerably thinner, but is now the most prominent part, as it has not shrunk as fast as the granuloma.

Post-mortem, November 29.—An incision through the bony tumor shows numerous alveoli filled with soft granulatous tissue containing very little pus. Directly above the scar on the lower surface is a large granuloma the size of a goose egg. The consistence of this is not soft as usual, and contains less pus. In this actinomyces were found.

In the wall of the small intestines was located a few hard small nodules the size of millet seeds, containing a dry mass, consisting mostly of limesalts. No actinomyces were found. Other internal organs sound. Carcass condemned.

No. 534819.

Red steer, white star, white left shoulder and rump, dehorned; received August 16.

The right lower maxilla is immensely swollen from the ramus to the angle. The swelling is bony and covered with a thick fibrous layer, which extends up over the cheek towards the eye. Underneath it occupies the whole intermaxillary space and has a dependence of 4 inches.

The treatment commenced August 18 with a daily dose of 12 grams and was continued until September 25. The fibrous parts of the swelling had by this time shrunk considerably, leaving the tumor hard as bone. The swelling on the upper jaw had almost disappeared, only in the submaxillary space there remained a good deal of fibrous covering. The treatment was then continued for three weeks more without much improvement.

TREATISE
Post-mortem, November 29.—The fibrous tissue covering the swelling contained a few deposits of soft tissue, while the bony cavities filled with the same and a few filled with pus. No internal organs condemned.

No. 48087.

Red steer, white star and shoulder, hornless; received August 30 from Kansas City.

The right ramus of the lower maxilla is swollen to an enormous size. The swelling fills the entire intermaxillary space from the chin to the neck and extends up over the right cheek toward the eye. The deeper parts of the swelling are hard, covered with a thick layer of fibrous tissue, which on the lower part of the swelling is 4 or 5 inches thick. There is located at this point an ulcerating granuloma 6 to 8 inches in diameter and protruding 3 to 4 inches over the swollen margin of the surroundings. The surface of the granuloma is uneven, partly raw and bleeding, and partly covered with crusts of pus, which is constantly discharged through numerous minute openings on the surface. The ulcer has a very fetid odor. The skin covering the tumor is closely attached to the underlying tissue. The entire swelling was fully the size of a gallon jug.

Treatment was commenced September 1 with a daily dose of 15 grams and was continued until November 1, with proper intervals, two of which extended over a week each. The steer showed a pronounced iodism, and, though the manure constantly was rather hard, the steer did not lose in condition. The ulcerating surface of the granuloma soon began to dry up and no more pus was discharged. The swollen indurated margins shrunk and contracted considerably, and by this contraction the whole granuloma, which then had shrunk to the size of a clinched fist, was expelled, leaving a dry scar. The softer parts of the swelling, especially in the submaxillary space and the parts extending up over the cheek, disappeared almost entirely, leaving the bony part closely covered by the indurated skin.

Post-mortem, November 29.—The skin covering swelling is indurated and about three-fourths of an inch thick. On the lower part of the tumor is seen a white contracted cicatrix 3 to 4 inches in diameter, and in the thin fibrous covering of the bony swelling were a few small centers of reddish granular tissue. A section through the bone shows this spongy and filled with numerous centers and pockets containing yellow pus of a rather slimy character, and several cavities filled with soft red tissue interrupted by the characteristic small yellow spots. All the surrounding lymph glands were perfectly sound and no lesions were found in the internal organs. The carcass, though it was in splendid condition, was condemned.

No. 48247.

White roan steer, horns; received August 30 from Kansas City. Case of immense swelling of right lower maxilla with ulcerating granuloma. Case of above number (48087).

Post-mortem, November 29.—The granuloma had not disappeared altogether, shrunk to the size of a hen's egg and was rather hard and dry. The fibrous covering the bony swelling contained several small centers of soft tissue, and a section through the bony swelling shows this to be spongy, with numerous cavities filled with soft red tissue and pus. The lymph glands on the left side of the face from the eye down to the nose, is immensely enlarged, of very consistency, the covering skin only a little indurated. Carcass condemned.

No. 534031.

White steer, dehorned; received August 22. Left side of the face from the eye down to the nose, is immensely enlarged, of very consistency, the covering skin only a little indurated. Carcass condemned.

most prominent part, 3 inches below the eye, there is an ulcer 4 by 5 inches in diameter and only protruding a little over the surrounding parts. On the surface of the ulcer, which is covered by dry pus crusts, 3 fistulas open out, constantly discharging a little yellow inodorous pus.

Treatment was commenced August 24 with a daily dose of 15 grams, and was continued until October 7, with proper intervals. By this time the fibrous part of the swelling had shrunk considerably, leaving the rest hard like bone. The ulcer had healed up, but one of the fistulas was still discharging a little pus. Medicine was again administered for two weeks without any noticeable improvement as to the size of the swelling, but no more pus was discharged from the fistula, which shortly afterward healed up. The steer showed no symptoms of iodism during the entire treatment.

Post-mortem, November 29.—The bony swelling was spongy, but contained no pus and only a few centers of soft tissue. Two cords of white connective tissue extended from the contracted cicatrices on the surface toward the deeper parts. The lymph glands on the head were sound. No internal lesions. Carcass condemned.

No. 39989.

Red hornless steer, white star, white spot on right hip and left flank; received August 28.

The right side of the lower maxilla is enormously swollen. The deeper parts of the tumefaction are of a bony consistency, but are covered with a thick layer of fibrous tissue, which on the lower part is about three inches thick and is closely attached to the skin. At this place there is an ulcerating granuloma, 5 to 7 inches in diameter, protruding 3 to 4 inches over the thick swollen margins of the surrounding parts. (See picture of No. 545524.)

Treatment was commenced August 30 with a daily dose of 15 grams and was continued until October 20, with proper intervals. The steer showed a pronounced iodism and the granuloma dried up and shrunk rapidly. When the treatment was stopped there was only left a contracted scar, the fibrous parts of the swelling had shrunk considerably, and afterward continued to shrink.

Post-mortem, November 29.—The bony swelling is covered by a thin layer of fibrous tissue, which on the lower part contains a few centers of soft red tissue, ranging in size from a pea to a bean. The internal tissues of the bone are spongy, with several pockets filled with soft tissue, but none filled with pus. The surrounding lymph glands are all sound. No internal lesions. Carcass was condemned.

No. 43159.

Black steer, white star, hornless; received August 30 from Kansas City.

Immense fibrous bony swelling of left lower maxilla, with ulcerating granuloma 6 to 8 inches in diameter. (See No. 545525.)

Treatment was commenced September 1 with a daily dose of 15 grams and was continued until November 1, with proper intervals. Though the steer showed a pronounced iodism, the tumor showed no tendency to heal up or shrink; in fact, the large and frequent doses of medicine had very little effect on it. The granuloma remained unchanged in size and continued to discharge drops of pus through minute openings in the surface. The fibrous parts of the tumefaction shrunk almost entirely, making the granuloma appear about twice as large as it was originally.

Post-mortem, November 29.—An incision through the granuloma showed this to consist of very soft red tissue, with numerous pus foci, ranging in size from a pin head to a pea. The internal part of the bony swelling was spongy, containing numerous centers of soft red tissue, the largest being about the size of a walnut. The lymph glands on the head were sound. No internal lesion. Carcass was condemned.

TREATMENT

No. 130988.

Red steer, hornless, white spot on right shoulder; received September 5, 1892. In sublingual space on left side is located a fibrous tumor the size of a coconut. The tumor was slightly fluctuating, and was opened with a knife. It inclosed a deeply situated abscess, which contained from 1 to 3 ounces of good yellow pus. Treatment was commenced September 7 with a daily dose of 12 grams, and was continued until October 10, by which time the tumor had disappeared, and only leaving a fibrous thickening in the skin. About October 20 the steer was considered cured.

Post-mortem, November 29.—No traces of the tumor left, except a slight induration of the skin. In the upper part of the right lung was located a tumor the size of a clinched fist. In the left lung in the same place was a tumor the size of a walnut. Both tumors consisted of fibrous tissue, and contained several cavities filled with pus and granulosomatous tissue. The microscopic examination proved them to be actinomycomas. The carcass was condemned.

No. 47067.

Red dehorned steer; received August 16. On the left cheek are located seven hard fibrous tumors, ranging in size from a hazelnut to a walnut. They are situated in the short connective tissue under the skin, and can only be moved slightly. In the submaxillary space is located another one the size of a double clinched fist. Treatment was commenced August 18, with a daily dose of 10 grams, and was continued until October 1 with proper intervals. By this time the small tumors in the cheek had disappeared, each leaving a small fibrous thickening in the skin. The tumor underneath had shrunk to the size of a hen's egg. About October 20 the steer was considered cured.

Post-mortem, November 29.—No traces of the tumors left, except a slight induration in the skin under the throat. In the upper part of the left lung were found three tumors about the size of a walnut. In the right lung a similar one the size of a hazelnut. All of them contained soft granulosomatous tissue and pus. The microscopic examination proved the pus to contain actinomyces. The carcass was condemned.

No. 130916.

Red steer, white face, horns; received August 30 from Kansas City. Immense fibrous bony swelling of left lower maxilla, with ulcerating granulation. (See No. 545524.) Treatment was commenced September 1 with a daily dose of 12 grams, and was continued until October 25, with proper intervals. The steer showed symptoms of iodism. The granuloma shrunk considerably, but did not dry up. The parts of the swelling were reduced.

Post-mortem, November 29.—The surface of the external granuloma is covered with a layer of soft red tissue, with numerous foci the size of small peas. The fibrous covering on the bony swelling consists of soft tissue. The internal parts of the bony swelling are spongy, with traces of soft tissue the size of hazelnuts. In the wall of the small internal cavities are located a few small hard nodules, containing a green colored detritus consisting mostly of lime salts. The microscopic examination proved them to be actinomycomas. No other lesions internally. Carcass was condemned.

No. 44007.

— white on left shoulder and brisket; received August 30 from Kansas City. Immense fibrous bony swelling of left lower maxilla, with ulcerating granulation. (See No. 545524.) Treatment was commenced September 1 with a daily dose of 12 grams, and was continued until October 25, with proper intervals. The steer showed symptoms of iodism. The granuloma shrunk considerably, but did not dry up. The parts of the swelling were reduced.

TREATMENT OF LUSK.

November 26.—The bony swelling contained a few centers with pus. No traces of the other tumor left. Lymph glands on head sound. There was a fibrous induration the size of a hen's egg, containing several centers filled with pus and soft tissue. Microscopical examination proved actinomycosis. Carcass was condemned.

No. 46510.

Red steer, white star; received September 5.

Bony swelling of lower maxilla on right side with large ulcerating granular end. Case similar to No. 48087.

Treatment was commenced September 7 with a daily dose of 15 grams and was continued November 1 with proper intervals. The granuloma dried up and fell altogether, only leaving a large contracted cicatrix. The thick induration covering the bony swelling were reduced to a thin layer of connective tissue as much thick.

Post-mortem, November 26.—An incision through the bony part of the swelling shows a sponge. In the lower part of it, just inside the scar left by the granuloma, was a large sinus the size of a hen's egg, and filled with the characteristic soft mass with the small yellow spots in. No pus could be squeezed out of the cut. The rest of the swelling contained neither pus nor soft tissue. No internal lymph glands on head sound. Carcass was condemned.

No. 48155.

Red steer, horns, spotted, white star; received August 30 from Kansas City.

The left side of the face from the eye down to the nose is immensely swollen. The swelling is as hard as bone and the covering skin is thick and indurated. Two or three openings on the surface, discharging yellow pus containing actinomy-

ces. Treatment was commenced September 1 with a daily dose of 15 grams, and was continued November 26 with proper intervals. By this time the tumor had become smaller, and the fistulas had healed up, each leaving a small contracted opening. Some time later the steer was killed six weeks later.

Post-mortem, November 26.—The skin is closely attached to the bony swelling. An incision through the bony swelling shows the internal tissue spongy, but containing neither pus nor soft tissue. The lymph glands on the head were sound and no internal lesions found. The carcass was condemned.

No. 35972.

Red steer, horns, received August 28, 1892; symptoms and treatment exactly as in number 48155.

Post-mortem, November 26.—The internal spongy part of the bony swelling contained a pocket the size of a robin's egg filled with pus. In the fibrous covering there were a few centers of soft tissue the size of beans. Lymph glands on head sound. No internal lesions. Carcass condemned.

No. 35953.

Roan steer, horns; received August 28.—On the right side of the face below the eye there is a hard bony swelling the size of a goose egg. In connective tissue in the submaxillary space is located a hard fibrous tumor as clinched fist.

Treatment was commenced August 30 with a daily dose of 10 grams, and continued until October 7, with proper intervals. By this time the tumor is

maxillary space had completely disappeared, while the bony swelling remained almost unchanged.

Post-mortem, November 29.—No traces of the fibrous tumor left. Surrounding lymph glands all sound. An incision through the bony swelling proved it to be spongy with numerous centers of soft tissue. No internal lesions. Carcass was condemned.

No. 39955.

White steer, rudiments of horns; received August 28.

Large fibrous, bony swelling of left lower jaw, with ulcerating granuloma 4 to 5 inches in diameter. (See No. 545524.) On the right side of the face a couple of inches below the eye there is a small, flat, bony swelling.

Treatment was commenced August 30 with a daily dose of 12 grams and was continued until October 25, with proper intervals. The fibrous part of the tumefaction shrunk almost entirely and the granuloma dried up and disappeared, leaving a contracted scar not larger than a silver dollar. The steer showed pronounced iodism.

Post-mortem, November 29.—No traces of actino in the thin fibrous cover of the bony swelling. This one, however, contained several cavities filled with soft tissue and pus. The small bony swelling on the upper jaw was solid and contained no traces of the disease. The lymph glands on the head were sound. No internal lesions. Carcass was condemned.

No. 531593.

Spotted brown steer, dehorned, white star; received August 22.

Immense fibrous bony swelling of left lower maxilla, with ulcerating granuloma, 5 to 7 inches in diameter. (Case similar to No. 545524.)

Treatment was commenced August 24, with a daily dose of 12 grams, and was continued until October 25, with proper intervals. The steer showed plain symptoms of iodism, and the fibrous parts of the tumor shrunk considerably. The granuloma did not dry up, but a piece of it, about one-third, was expelled by the shrinking of the fibrous surroundings. Medicine was again administered for two weeks, but without any noticeable improvement.

Post-mortem, November 29.—The thick induration in the skin on the bony swelling contained several centers of soft tissue the size of hazelnuts. The bony part of the swelling was spongy, with numerous pockets, filled with pus and soft tissue. The inside of the right lower maxilla was slightly affected in the same way. The lymph glands on the head were sound. No internal lesions. Carcass condemned.

No. 545543.

Red steer, hornless; received August 16.

Immense fibrous bony swelling of right lower maxilla, with ulcerating granuloma 5 to 6 inches in diameter. (Case similar to No. 545524.)

Treatment was commenced August 18, with a daily dose of 12 grams, and was continued until October 25, with proper intervals. By this time the granuloma had dried up and disappeared, leaving a white contracted cicatrix. The fibrous parts of the swelling had also shrunk considerably. The steer showed pronounced iodism.

Post-mortem, November 29.—The bony swelling is covered by a thin layer of fibrous tissue. The internal tissue of the bone is spongy, with one large cavity the size of a clinched fist filled with soft tissue which, on the lower part, is covered by the scar left from the external granuloma. No pus can be squeezed out of the cut surface. The lymph glands on the head were all sound. No internal lesions. Carcass was condemned.

Post-mortem, November 29.—The fibrous tissue covering the lower part of the bony swelling contained a few deposits of soft tissue, while the bony swelling contained several cavities filled with the same and a few filled with pus. No internal lesions. Carcass condemned.

No. 48087.

Red steer, white star and shoulder, hornless; received August 30 from Kansas City.

The right ramus of the lower maxilla is swollen to an enormous size. The swelling fills the entire intermaxillary space from the chin to the neck and extends up over the right cheek toward the eye. The deeper parts of the swelling are hard, covered with a thick layer of fibrous tissue, which on the lower part of the swelling is 4 or 5 inches thick. There is located at this point an ulcerating granuloma 6 to 8 inches in diameter and protruding 3 to 4 inches over the swollen margin of the surroundings. The surface of the granuloma is uneven, partly raw and bleeding, and partly covered with crusts of pus, which is constantly discharged through numerous minute openings on the surface. The ulcer has a very fetid odor. The skin covering the tumefaction is closely attached to the underlying tissue. The entire swelling was fully the size of a gallon jug.

Treatment was commenced September 1 with a daily dose of 15 grams and was continued until November 1, with proper intervals, two of which extended over a week each. The steer showed a pronounced iodism, and, though the manure constantly was rather hard, the steer did not lose in condition. The ulcerating surface of the granuloma soon began to dry up and no more pus was discharged. The swollen indurated margins shrunk and contracted considerably, and by this contraction the whole granuloma, which then had shrunk to the size of a clinched fist, was expelled, leaving a dry scar. The softer parts of the swelling, especially in the submaxillary space and the parts extending up over the cheek, disappeared almost entirely, leaving the bony part closely covered by the indurated skin.

Post-mortem, November 29.—The skin covering swelling is indurated and about three-fourths of an inch thick. On the lower part of the tumefaction is seen a white contracted cicatrix 3 to 4 inches in diameter, and in the thin fibrous covering of the bony swelling were a few small centers of reddish granulatous tissue. A section through the bone shows this spongy and filled with numerous centers and pockets containing yellow pus of a rather slimy character, and several cavities filled with soft red tissue interrupted by the characteristic small yellow spots. All the surrounding lymph glands were perfectly sound and no lesions were found in the internal organs. The carcass, though it was in splendid condition, was condemned.

No. 48247.

White roan steer, horns; received August 30 from Kansas City.

Immense swelling of right lower maxilla with ulcerating granuloma. Case similar to above number (48087).

Post-mortem, November 29.—The granuloma had not disappeared altogether. It shrunk to the size of a hen's egg and was rather hard and dry. The fibrous tissue covering the bony swelling contained several small centers of soft tissue. An incision through the bony swelling shows this to be spongy, with numerous pockets and cavities filled with soft red tissue and pus. The lymph glands on head were sound. Carcass condemned.

No. 534031.

White steer, dehorned; received August 22.

The left side of the face from the eye down to the nose, is immensely swollen. The swelling is of a bony consistency, the covering skin only a little indurated. On the

most prominent part, 3 inches below the eye, there is an ulcer 4 by 5 inches in diameter and only protruding a little over the surrounding parts. On the surface of the ulcer, which is covered by dry pus crusts, 3 fistulas open out, constantly discharging a little yellow inodorous pus.

Treatment was commenced August 24 with a daily dose of 15 grams, and was continued until October 7, with proper intervals. By this time the fibrous part of the swelling had shrunk considerably, leaving the rest hard like bone. The ulcer had healed up, but one of the fistulas was still discharging a little pus. Medicine was again administered for two weeks without any noticeable improvement as to the size of the swelling, but no more pus was discharged from the fistula, which shortly afterward healed up. The steer showed no symptoms of iodism during the entire treatment.

Post-mortem, November 29.—The bony swelling was spongy, but contained no pus and only a few centers of soft tissue. Two cords of white connective tissue extended from the contracted cicatrices on the surface toward the deeper parts. The lymph glands on the head were sound. No internal lesions. Carcass condemned.

No. 39989.

Red hornless steer, white star, white spot on right hip and left flank; received August 28.

The right side of the lower maxilla is enormously swollen. The deeper parts of the tumefaction are of a bony consistency, but are covered with a thick layer of fibrous tissue, which on the lower part is about three inches thick and is closely attached to the skin. At this place there is an ulcerating granuloma, 5 to 7 inches in diameter, protruding 3 to 4 inches over the thick swollen margins of the surrounding parts. (See picture of No. 545524.)

Treatment was commenced August 30 with a daily dose of 15 grams and was continued until October 20, with proper intervals. The steer showed a pronounced iodism and the granuloma dried up and shrunk rapidly. When the treatment was stopped there was only left a contracted scar, the fibrous parts of the swelling had shrunk considerably, and afterward continued to shrink.

Post-mortem, November 29.—The bony swelling is covered by a thin layer of fibrous tissue, which on the lower part contains a few centers of soft red tissue, ranging in size from a pea to a bean. The internal tissues of the bone are spongy, with several pockets filled with soft tissue, but none filled with pus. The surrounding lymph glands are all sound. No internal lesions. Carcass was condemned.

No. 48159.

Black steer, white star, hornless; received August 30 from Kansas City.

Immense fibrous bony swelling of left lower maxilla, with ulcerating granuloma 6 to 8 inches in diameter. (See No. 545525.)

Treatment was commenced September 1 with a daily dose of 15 grams and was continued until November 1, with proper intervals. Though the steer showed a pronounced iodism, the tumor showed no tendency to heal up or shrink; in fact, the large and frequent doses of medicine had very little effect on it. The granuloma remained unchanged in size and continued to discharge drops of pus through minute openings in the surface. The fibrous parts of the tumefaction shrunk almost entirely, making the granuloma appear about twice as large as it was originally.

Post-mortem, November 29.—An incision through the granuloma showed this to consist of very soft red tissue, with numerous pus foci, ranging in size from a pin head to a pea. The internal part of the bony swelling was spongy, containing numerous centers of soft red tissue, the largest being about the size of a walnut. The lymph glands on the head were sound. No internal lesion. Carcass was condemned.

No. 130988.

Red steer, hornless, white spot on right shoulder; received September 5, 1892.

In sublingual space on left side is located a fibrous tumor the size of a coconut. The tumor was slightly fluctuating, and was opened with a knife. It inclosed a deeply situated abscess, which contained from 1 to 3 ounces of good yellow pus.

Treatment was commenced September 7 with a daily dose of 12 grams, and was continued until October 10, by which time the tumor had disappeared, and only leaving a fibrous thickening in the skin. About October 20 the steer was considered cured.

Post-mortem, November 29.—No traces of the tumor left, except a slight induration of the skin. In the upper part of the right lung was located a tumor the size of a clinched fist. In the left lung in the same place was a tumor the size of a walnut. Both tumors consisted of fibrous tissue, and contained several cavities filled with pus and granulosomatous tissue. The microscopic examination proved them to be actinomycomas. The carcass was condemned.

No. 47067.

Red dehorned steer; received August 16.

On the left cheek are located seven hard fibrous tumors, ranging in size from a hazelnut to a walnut. They are situated in the short connective tissue under the skin, and can only be moved slightly. In the submaxillary space is located another one the size of a double clinched fist.

Treatment was commenced August 18, with a daily dose of 10 grams, and was continued until October 1 with proper intervals. By this time the small tumors in the cheek had disappeared, each leaving a small fibrous thickening in the skin. The tumor underneath had shrunk to the size of a hen's egg. About October 20 the steer was considered cured.

Post-mortem, November 29.—No traces of the tumors left, except a slight induration in the skin under the throat. In the upper part of the left lung were found three tumors about the size of a walnut. In the right lung a similar one the size of a hazelnut. All of them contained soft granulosomatous tissue and pus. The microscopic examination proved the pus to contain actinomyces. The carcass was condemned.

No. 130916.

Red steer, white face, horns; received August 30 from Kansas City.

Immense fibrous bony swelling of left lower maxilla, with ulcerating granuloma 6 to 8 inches in diameter. (See No. 545524.)

Treatment was commenced September 1 with a daily dose of 12 grams, and was continued until October 25, with proper intervals. The steer showed symptoms of iodism. The granuloma shrunk considerably, but did not dry up. The fibrous parts of the swelling were reduced.

Post-mortem, November 29.—The surface of the external granuloma is ulcerated. An incision through it shows that it consists of soft red tissue, with numerous pus foci the size of small peas. The fibrous covering on the bony swelling contained traces of soft tissue. The internal parts of the bone were spongy, with a few centers of soft tissue the size of hazelnuts. In the wall of the small intestines were located a few small hard nodules, containing a green colored detritus mass, consisting mostly of lime salts. The microscopic examination proved them not to be actinomycotic lesions. No other lesions internally. Carcass was condemned.

No. 44007.

Red roan dehorned steer, white on left shoulder and brisket; received August 16.

Immense fibrous, bony swelling of right lower maxilla, with ulcerating granuloma 6 to 7 inches in diameter. (See No. 545524.)

Treatment was commenced August 18 with a daily dose of 12 grams and was continued until October 10, with proper intervals. The steer showed pronounced iodism. The granuloma dried up, but only shrunk a little. The fibrous parts of the swelling were reduced somewhat in size. Medicine was again administered from October 20 to November 1, by which time the granuloma had shrunk to the size of a hen's egg, and the fibrous parts had disappeared almost entirely.

Post-mortem, November 29.—The external granuloma, which is about the size of a walnut, is rather hard, having a dry surface. It contains no pus foci, but extends up into a cavity in the bony swelling the size of a goose egg. Under the peritoneal covering on the small intestines were located a few small hard nodules, containing a greenish detritus mass with considerable lime salts in it. No actinomyces was found by the microscopical examination. On the surface of the liver was located an abscess the size of a hazelnut, filled with yellow pus. This also was free from the actinomyces. The carcass was condemned.

No. 45902.

Red steer, dehorned; received September 5, 1892.

The right ramus of the lower maxilla below the first molar is swollen to the size of a double clinched fist. The skin covering it is thickened and indurated, being about 1 inch thick on the lower part.

The treatment was commenced September 7, with a daily dose of 12 grams, and was continued until November 1. The steer showed a pronounced iodism, but the tumor shrunk only very little.

Post-mortem, November 29.—The induration covering the bony swelling contains a few centers of soft granulomatous tissue the size of hazelnuts. The internal parts of the bone were a little spongy, but contained no pus cavities. No lesions in the lymphatic glands and no internal lesions. The carcass was condemned.

No. 48042.

Red steer, partly dehorned; received August 30 from Kansas City.

On the right side of the face, 1 inch below the eye, is located a bony hard swelling the size of a clinched fist. The skin that covers the swelling is thick and indurated.

Treatment was commenced September 1 with a daily dose of 12 grams and continued until October 30, with proper intervals. The tumor remained almost unchanged, only the induration in the skin becoming thinner.

Post-mortem, November 29.—The internal parts of the bony swelling were very spongy, with several pockets filled with soft granulomatous tissue, but without any pus. A cord of white connective tissue extended from the center of the swelling down to the socket of the third molar in the upper jaw, which was loose. The lymph glands on the head were all sound. No internal lesions. Carcass condemned.

No. 39978.

Dark red steer, horns; received August 28.

On the right side of the face a little below the eye there is a flat bony swelling as large as the palm of a hand, and protruding about one inch. The skin covering the swelling is a little indurated. In the submaxillary space is located a hard fibrous tumor the size of a double clinched fist lying loose in the connective tissue under the skin.

Treatment was commenced August 30 with a daily dose of 10 grams, and was continued until October 15 with proper intervals. The bony swelling remained unchanged, while the tumor in submaxillary space completely disappeared.

Post-mortem, November 29.—The bony swelling contained a few centers with soft tissue, but no pus. No traces of the other tumor left. Lymph glands on head sound. In the left lung was a fibrous induration the size of a hen's egg, containing several small pockets filled with pus and soft tissue. Microscopical examination proved them to be actinomycomas. Carcass was condemned.

No. 48510.

Red steer, hornless, white star; received September 5.

Immense bony swelling of lower maxilla on right side with large ulcerating granuloma on lower end. Case similar to No. 48087.

Treatment was commenced September 7 with a daily dose of 15 grams and was continued until November 1 with proper intervals. The granuloma dried up and disappeared altogether, only leaving a large contracted cicatrix. The thick indurations which covered the bony swelling were reduced to a thin layer of connective tissue half an inch thick.

Post-mortem, November 29.—An incision through the bony part of the swelling shows this to be spongy. In the lower part of it, just inside the scar left by the granuloma, there was a large sinus the size of a hen's egg, and filled with the characteristic soft red tissue with the small yellow spots in. No pus could be squeezed out of the cut surface. The rest of the swelling contained neither pus nor soft tissue. No internal lesions. Lymph glands on head sound. Carcass was condemned.

No. 48155.

Black steer, hornless, spotted, white star; received August 30 from Kansas City.

All the left side of the face from the eye down to the nose is immensely swollen. The swelling is hard as bone and the covering skin is thick and indurated. Two or three fistulas open out on the surface, discharging yellow pus containing actinomycetes.

Treatment was commenced September 1 with a daily dose of 15 grams, and was continued until October 20 with proper intervals. By this time the tumor had shrunk to its capacity the fistulas had healed up, each leaving a small contracted scar which remained closed until the steer was killed six weeks later.

Post-mortem, November 29.—The skin is closely attached to the bony swelling. An incision through the bony swelling shows the internal tissue spongy, but containing neither pus nor soft tissue. The lymph glands on the head were sound and no internal lesions found. The carcass was condemned.

No. 39972.

Red steer, horns, received August 28, 1892; symptoms and treatment exactly like above number (48155).

Post-mortem, November 29.—The internal spongy part of the bony swelling contained a pocket the size of a robin's egg filled with pus. In the fibrous covering of the bone there were a few centers of soft tissue the size of beans. Lymph glands on head sound. No internal lesions. Carcass condemned.

No. 39953.

Roan steer, horns; received August 28.—On the right side of the face, 2 inches below the eye there is a hard bony swelling the size of a goose egg. In the loose connective tissue in the submaxillary space is located a hard fibrous tumor as large as a clinched fist.

Treatment was commenced August 30 with a daily dose of 10 grams, and was continued until October 7, with proper intervals. By this time the tumor in the sub-

maxillary space had completely disappeared, while the bony swelling remained almost unchanged.

Post-mortem, November 29.—No traces of the fibrous tumor left. Surrounding lymph glands all sound. An incision through the bony swelling proved it to be spongy with numerous centers of soft tissue. No internal lesions. Carcass was condemned.

No. 39955.

White steer, rudiments of horns; received August 28.

Large fibrous, bony swelling of left lower jaw, with ulcerating granuloma 4 to 5 inches in diameter. (See No. 545524.) On the right side of the face a couple of inches below the eye there is a small, flat, bony swelling.

Treatment was commenced August 30 with a daily dose of 12 grams and was continued until October 25, with proper intervals. The fibrous part of the tumefaction shrunk almost entirely and the granuloma dried up and disappeared, leaving a contracted scar not larger than a silver dollar. The steer showed pronounced iodism.

Post-mortem, November 29.—No traces of actino in the thin fibrous cover of the bony swelling. This one, however, contained several cavities filled with soft tissue and pus. The small bony swelling on the upper jaw was solid and contained no traces of the disease. The lymph glands on the head were sound. No internal lesions. Carcass was condemned.

No. 531593.

Spotted brown steer, dehorned, white star; received August 22.

Immense fibrous bony swelling of left lower maxilla, with ulcerating granuloma, 5 to 7 inches in diameter. (Case similar to No. 545524.)

Treatment was commenced August 24, with a daily dose of 12 grams, and was continued until October 25, with proper intervals. The steer showed plain symptoms of iodism, and the fibrous parts of the tumor shrunk considerably. The granuloma did not dry up, but a piece of it, about one-third, was expelled by the shrinking of the fibrous surroundings. Medicine was again administered for two weeks, but without any noticeable improvement.

Post-mortem, November 29.—The thick induration in the skin on the bony swelling contained several centers of soft tissue the size of hazelnuts. The bony part of the swelling was spongy, with numerous pockets, filled with pus and soft tissue. The inside of the right lower maxilla was slightly affected in the same way. The lymph glands on the head were sound. No internal lesions. Carcass condemned.

No. 545543.

Red steer, hornless; received August 16.

Immense fibrous bony swelling of right lower maxilla, with ulcerating granuloma 5 to 6 inches in diameter. (Case similar to No. 545524.)

Treatment was commenced August 18, with a daily dose of 12 grams, and was continued until October 25, with proper intervals. By this time the granuloma had dried up and disappeared, leaving a white contracted cicatrix. The fibrous parts of the swelling had also shrunk considerably. The steer showed pronounced iodism.

Post-mortem, November 29.—The bony swelling is covered by a thin layer of fibrous tissue. The internal tissue of the bone is spongy, with one large cavity the size of a clinched fist filled with soft tissue which, on the lower part, is covered by the scar left from the external granuloma. No pus can be squeezed out of the cut surface. The lymph glands on the head were all sound. No internal lesions. Carcass was condemned.

No. 45591.

Red steer, rudiments of horns; received August 30 from Kansas City.

Swelling of facial bones, left side from eye to nose, with ulcer size of the palm of a hand (see No. 130915).

Treatment was commenced September 1 with a daily dose of 12 grams and was continued until October 25 with proper intervals. The steer showed pronounced iodism. The ulcer dried up, only leaving a small cicatrix. The fibrous parts of the swelling shrunk almost completely, leaving the bony part covered by the slightly indurated skin.

Post-mortem, November 29.—The bony swelling was spongy and contained several centers of soft tissue, but no pus. The lymph glands on head were sound. Small actinomycotic tumor in the lung. Carcass was condemned.

No. 39951.

Red steer, large horns, white stripe across forehead; received August 28, 1892.

Immense fibrous bony swelling of right lower maxilla. (See No. 545524.) Ulcerating granuloma, 4 to 5 inches in diameter.

Treatment was commenced August 30 with a daily dose of 15 grams and was continued until October 25 with proper intervals. The steer showed pronounced iodism, and the fibrous parts of the tumor shrunk considerable. The granuloma dried up and shrunk to the size of a walnut.

Post-mortem, November 29.—The fibrous part of the swelling contained several centers of soft tissue, especially in the lower part around the scar left from the granuloma. The remaining part of this was rather hard and dry. The internal tissue of the bone was spongy with a few centers of soft tissue and pockets filled with pus. Just inside the granuloma was a large cavity filled with soft tissue. The lymph glands on head were sound. No internal lesions. Carcass condemned.

No. 39981.

Speckled steer, dehorned; received August 28.

Immense fibrous bony swelling of right lower jaw, with ulcerating granuloma. (Case similar to No. 545524.)

Treatment was commenced August 30, with a daily dose of 15 grams, and was continued until November 1 with proper intervals. Though the steer showed a fair degree of iodism, the effect of the medicine on the tumefaction was scarcely noticeable. The granuloma only dried up around the edges, but continued to ulcerate in the central part of the surface, with a very fetid odor. The surrounding fibrous swelling shrunk somewhat, which made the granuloma appear more prominent than it did originally. In spite of the large and frequent doses of medicine no further improvement was obtained.

Post-mortem, November 29.—The head had been removed by the butchers before examination. No internal lesions. Carcass was condemned.

No. 39966.

Light red steer, hornless; received August 28.

On the right lower maxilla, below the third molar, is located a hard bony swelling the size of a goose egg. The skin covering the swelling is thick and indurated, and closely attached to the underlying tissue.

Treatment was commenced August 30, with a daily dose of 10 grams, and was continued until October 15 with proper intervals. The first two weeks the swelling increased considerably in size, and became a trifle larger than a clinched fist. The dose was then increased to 12 grams, and later on to 15 grams, but in spite of this the

steer, which weighed about 1,100 pounds only showed obscure symptoms of iodism. The growth of the tumor was checked, but it did not shrink any.

Post-mortem, November 29.—The head of the steer had been removed by the butchers before it was examined. No internal lesions. Carcass condemned.

No. 59805.

Brindle steer, horns; received August 30, from Kansas City.

Extensive swelling of facial bones on right side. (Case similar to No. 130915, but without granuloma).

Treatment was commenced September 1, with a daily dose of 15 grams, and was continued until November 1, with proper intervals. Steer showed a pronounced iodism, but the tumor only shrunk very little.

Post-mortem, November 29.—The skin covering the bony swelling was thick and indurated. The internal tissue of the tumefaction spongy with numerous centers of soft tissue and pockets filled with pus. Lymph glands on head sound. No internal lesions. Carcass condemned.

No. 59959.

Red steer, hornless, brindle head and neck; received August 28.

Immense fibrous bony swelling of left lower jaw. Ulcerating granuloma 6 to 7 inches in diameter, and 2 to 3 inches thick. (Case similar to No. 545524.)

Treatment was commenced August 30 with a daily dose of 15 grams, and was continued until October 25, with proper intervals. The steer showed a pronounced iodism. The fibrous part of the tumor shrunk almost entirely. Granuloma dried up and was drawn in. By November 12 it had disappeared, only leaving a large white contracted cicatrix.

Post-mortem, November 29.—The fibrous parts of the swelling around the cicatrix contained a few centers of soft tissue the size of hazel nuts. The bony swelling was spongy with a few pockets containing yellow inodorous pus. Surrounding lymph glands were sound. No internal lesions. The carcass was condemned.

No. 48043.

Red steer, white star, hornless; received August 30, from Kansas City.

Bony swelling of the left side of the face, from the eye to the nose. (Case similar to No. 130915.)

Treatment was commenced September 1, with a daily dose of 12 grams, and was continued until October 25th, with proper intervals. The steer showed the usual symptoms of iodism. The tumor remained unchanged in size, only the thick indurated skin covering it became a trifle thinner.

Post-mortem November 29.—No traces of actino in the indurated skin. The internal tissue of the bony swelling was spongy, and contained a few centers of soft tissue the size of hazel nuts. The lymph glands on the head were sound. No internal lesions. Carcass was condemned.

No. 45887.

Red steer, hornless, white star; received September 5.

Immense fibrous bony swelling of left lower maxilla, with ulcerating granuloma 6 to 7 inches in diameter. (See 545524.)

Treatment was commenced September 7 with a daily dose of 12 grams, and was continued until October 25 with proper intervals. The steer showed a pronounced iodism and the granuloma soon began to dry up and shrink, and finally disappeared entirely. The thick fibrous induration in the skin was reduced considerably.

Post-mortem, November 29.—The fibrous tissue on the lower part of the tumefaction inclosed a few small centers of soft tissue. The internal parts of the bony swelling were spongy, with several pockets and centers of pus and soft tissue. One of these just inside the scar left by the external granuloma was the size of a hen's egg. The lymph glands on the head were sound. No internal lesions. Carcass was condemned.

No. 545544.

Dark red steer, white face and rump; received August 16.

Large fibrous bony swelling on left lower maxilla with ulcerating granuloma 4 to 5 inches in diameter. (See No. 545524.)

Treatment was commenced August 18, with a daily dose of 12 grams, and was continued until October 1 with proper intervals. The steer showed no symptoms of iodism and the tumor improved only slowly. The granuloma dried up and shrunk slightly, and so did the fibrous parts of the tumefaction. Medicine was again administered from October 15 to October 30, by which time the granuloma had disappeared and the swelling had been reduced considerably.

Post-mortem, November 29.—The internal parts of the swelling were spongy and contained several cavities filled with soft tissue, one of which, just inside the cicatrix left by the external granuloma, was the size of a walnut. The lymph glands on the head were sound. No internal lesions. Carcass condemned.

No. 39983.

Red steer, white star, hornless, white spot on shoulder; received August 28, 1892.

Large fibrous bony swelling of right lower maxilla with ulcerating granuloma 4 to 5 inches in diameter. (See 545524.)

Treatment was commenced August 30 with a daily dose of 12 grams and was continued until October 25, with proper intervals. The steer showed a pronounced iodism, the granuloma dried up and disappeared, and the fibrous part of the swelling was reduced considerably.

Post-mortem, November 29.—The dense fibrous tissue surrounding the scar left by the granuloma contained a few centers of soft tissue, the internal tissues of the bony swelling were spongy with several pockets filled with soft tissue, one of them corresponding to the cicatrix, being the size of a hen's egg. No internal lesions. Carcass was condemned.

No. 131026.

Light roan steer, horns; received September 5.

No. 131030.

Speckled steer, red head and neck; received September 5.

Large, fibrous, bony swelling of right lower maxilla with ulcerating granuloma 2 to 3 inches in diameter. Treatment was commenced September 7 with a daily dose of 12 grams, and was continued until October 28, with proper intervals. Both steers showed a pronounced iodism. The granuloma dried up and disappeared, and the fibrous parts shrunk considerably.

Post-mortem November 29.—No. 131026. The fibrous covering on the bony swelling showed no traces of actinomycosis. The internal tissue of the bone was spongy, and contained only a few small centers filled with soft tissue. The lymph glands on the head were sound. No internal lesions. As the steer was in a very poor condition the carcass was condemned.

No. 131030. The fibrous part of the swelling contained several centers of soft tissue. The internal parts of the bone were spongy, and contained several large pock-

ets with soft tissue, especially just inside the scar left by the external granuloma. No internal lesions. Carcass was condemned.

Though both steers showed exactly same external lesions, and received exactly the same treatment as to dose of medicine and length of time administered, and though they both apparently improved equally, the post-mortem examination showed that the medicine had had a much stronger effect on the internal parts of the tumefaction on the first one than on the other.

No. 130905.

Red speckled steer, horns; received August 30 from Kansas City.

Fibrous bony swelling of the left side of the face from eye to nose. (See No. 130915.)

Treatment commenced September 1 with a daily dose of 12 grams and was continued until October 25, with proper intervals.

The steer showed a pronounced iodism and the fibrous parts of the tumefaction shrunk considerably, leaving the bony swelling covered by the slightly indurated skin.

Post-mortem, November 29.—The thin fibrous covering of the bony swelling contained a few small centers of soft tissue. The internal tissue of the bone was spongy and contained several pockets filled with soft tissue and pus. The lymph glands on the head were sound. No internal lesions. Carcass was condemned.

No. 48089.

Red steer, hornless; received August 30 from Kansas City.

Immense swelling of the facial bones on right side from eye to nose. The covering skin is very thick and indurated. On the most prominent part, 3 inches below the eye, is located an ulcer, 4 to 5 inches in diameter. (Case similar to 130915.)

Treatment was commenced September 1 with a daily dose of 15 grams and was continued until October 25, with proper intervals. The steer showed a pronounced iodism and the fibrous parts of the swelling were reduced considerably, while the ulcer dried up and became covered with epidermis, leaving three small fistulous openings, which soon afterwards closed up.

Post-mortem, November 29.—Slight traces of soft tissue centers left in the indurated skin. The internal tissues of the bony swelling were spongy, but contained only a very few cavities, filled with soft tissue. The lymph glands on head were sound. No internal lesions. Carcass was condemned.

No. 545764.

Red steer, white star, small horns; received August 16, 1892.

The right lower maxilla is swollen from the mouth to the neck. The swelling is hard as bone near the mouth, while the posterior parts are soft.

Treatment was commenced August 18 with a daily dose of 10 grams, and was continued until September 12, when the soft parts of the swelling had disappeared, leaving a hard, bony tumor the size of a clinched fist on the lower edge of the under jaw near the chin.

The treatment was again commenced October 10 and continued until November 15, with proper intervals, but apparently without further improvement in the size of the tumor. The steer being in a rather poor condition was not killed with the first lot slaughtered on November 29.

Post-mortem, January 27, 1893.—In right lower maxilla is a bony swelling the size of a goose egg. A section through this shows it to consist of compact bone, which around the dental canal is spongy, and contained a little pus. The fifth molar was decayed. No internal lesions. Carcass passed as sound.

No. 130926.

White speckled cow, short horns; received September 12, 1892.

In the sublaryngeal space, on the right side, is located a hard, fibrous tumor the size of a double clinched fist lying loose in the connective tissue under the skin.

Treatment was commenced September 14 with a daily dose of 10 grams, and was continued until October 20, when the tumor had shrunk to the size of a hen's egg.

Medicine was again administered from November 13 till January 25 with one dose twice a week, which removed the last traces of the tumor.

Post-mortem, January 27, 1893.—No traces of the tumor left. A few small hard nodules in the wall of the small intestines. Lungs and liver sound. Carcass passed as sound.

No. 545750.

White speckled steer, with horns; received August 16, 1892.

The right upper maxilla a little below the eye is swollen considerably. The covering layer of the swelling is fibrous, the deeper parts bony. In sublingual space is located a hard, fibrous tumor the size of a clinched fist.

Treatment was commenced August 18 with a daily dose of 10 grams, and was continued until October 2 at proper intervals. By this time the tumor in sublingual space had disappeared, while the other one had grown considerably smaller. From November 1 until January 25 medicine was given about twice a week, only reducing the swelling a little.

Post-mortem, January 27, 1893.—No traces of actino in the fibrous covering on the bony swelling. This, however, is completely filled with actinomycotic new formations which extend into the maxillary sinus, and from here into the nasal fossa, where it may be felt by inserting a finger through the nostril.

Pleuritic adhesions in right lung. Internal organs sound. Carcass condemned.

No. 48071.

Red-spotted steer, hornless; received August 30, 1892, from Kansas City.

In right parotid region is located a hard, fibrous tumor the size of a goose egg, and a similar one is seen in sublaryngeal region on same side.

Treatment was commenced September 1, with a daily dose of 10 grams, and was continued until October 10, with proper intervals, by which time the steer was regarded as cured.

Post-mortem, January 27, 1893.—No traces of the tumors left. A few small hard nodules in the wall of the small intestines. Anterior lobes of both lungs adherent to pericardium. Carcass passed as sound.

No. 480496.

Dark red steer, dehorned; received August 16, 1892.

On both cheeks are located four to five small hard tumors the size of walnuts, and in sublaryngeal space one the size of a double clinched fist.

Treatment was commenced August 18 with a daily dose of 10 grams, and was continued until October 7, with proper intervals, by which time all the smaller tumors had disappeared and the largest one had shrunk to the size of a hen's egg. Medicine was again administered from November 1 to November 20, and soon afterwards the steer was cured.

Post-mortem, January 27, 1893.—No traces of the tumors left. A few small nodules in the wall of the small intestines. Other internal organs sound. Carcass passed as sound.

No. 6.

No tag. Dark red steer with horns, white belly, white spot on flank. The steer has been under treatment for the last three months, though not steadily. It had a fibrous tumor under the throat as big as a child's head. At the post-mortem examination on January 27, 1893, no traces of the disease were found, and the carcass was passed as sound.

No. 25875.

White steer, hornless; received September 12, 1892.

In left parotid and sublingual region is located a fibrous tumor the size of a child's head. The covering skin is connected with the tumor.

Treatment was commenced September 14 with a daily dose of 12 grams, and was continued until October 20, when the tumor had shrunk to the size of a goose egg.

From November 20 to January 25 medicine was again administered. The steer showed a pronounced iodism under the whole treatment.

Post-mortem, January 27, 1893.—No traces of the tumor left, except a fibrous induration in the skin where the tumor had been located. No internal lesions. Carcass passed as sound.

No. 59137.

Red Hereford steer, white head and shoulder; received August 28, 1892.

In left parotid region are located two tumors, the size of a hen's egg. Under the throat, a similar one, the size of a double-clinched fist.

Treatment was commenced August 30, with a daily dose of 12 grams, and was continued until October 25, when all three tumors disappeared, with the exception of a little induration in the skin.

Post-mortem, January 27, 1893.—Submaxillary glands a little swollen, but sound. The skin in parotid region and under the throat fibrous and indurated. No internal lesions. Carcass passed as sound.

No. 45957.

Red steer, white breast and back; received September 5, 1892.

In sublingual space on right side is located a fibrous tumor, the size of a child's head.

Treatment was commenced September 7, with a daily dose of 12 grams, and was continued until October 10, with proper intervals. By this time an abscess had formed, which was opened, and four to five ounces of good yellow pus evacuated. The tumor had shrunk considerably in size. Medicine was again administered from November 15 till January 20. The steer showed pronounced iodism, and the tumor shrunk rapidly.

Post-mortem, January 27, 1893.—No traces of the tumor left except a 1-inch thick fibrous induration in the skin. No internal lesions. Carcass passed as sound.

No. 130914.

Red steer, white face and belly, with horns; received August 30, from Kansas City.

In sublingual space is located a hard, fibrous tumor, the size of a child's head. Inside the lips are located several small granulomas.

Treatment was commenced September 1, with a daily dose of 12 grams, and was continued until October 15, with proper intervals. The granulomas in the mouth disappeared after two week's treatment, and the tumor under the throat shrunk rap-

idly, the steer showing a pronounced iodism. Medicine was again administered from November 1 until November 20, when the steer was regarded as cured, though it was in a rather poor condition.

Post-mortem, January 27, 1893.—Postpharyngeal glands indurated. No internal lesions. Carcass passed as sound.

No. 533770.

Red steer, white forehead and jaws, hornless; received August 22, 1892.

In right parotid region, just below the ear, is located a fibrous tumor the size of a clinched fist. In sublaryngeal space a similar tumor, the size of a child's head.

Treatment was commenced August 24, with a daily dose of 12 grams, and was continued until October 20, with proper intervals. By this time the tumor in parotid region had disappeared, and the other one shrunk to the size of a goose egg. Medicine was again administered from November 9 until January 10, when this tumor had almost disappeared.

Post-mortem, January 27, 1893.—No traces of the tumor left except a fibrous induration in the skin. No internal lesions. Carcass passed as sound.

No. 39995.

Roan steer, hornless; received August 28, 1892.

In sublaryngeal region is located a hard, fibrous tumor the size of a cocoanut.

Treatment was commenced on August 30, with a daily dose of 12 grams, and continued until October 20. The steer showed no symptoms of iodism, and the tumor remained almost unchanged. Treatment was continued from November 10 until January 20, but the tumor only shrunk very little.

Post-mortem, January 27, 1893.—Under the throat is located a fibrous tumor, the size of a child's head, containing several large centers of soft tissue and pus. The lymph glands on head sound. In the wall of the small intestines were located a few small nodules. Carcass condemned.

No. 39969.

Strawberry roan steer, dehorned; received August 28, 1892.

In left sublaryngeal space is located a fibrous tumor the size of a double clinched fist, and on the middle of the left cheek is a similar one the size of a goose egg.

Treatment was commenced August 30, with a daily dose of 10 grams, and was continued until October 15, with proper intervals. By this time the tumor on the cheek had almost disappeared, and the other one grown considerably smaller. Medicine was again administered from November 12 till January 15, when the steer was regarded as cured. The steer showed only slight symptoms of iodism.

Post-mortem, January 27, 1893.—No traces of the tumors left. No internal lesions. Carcass passed as sound.

No. 545511.

Light red steer, dehorned; received August 16, 1892.

In sublaryngeal space, on left side, is located a tumor the size of a child's head. On the lower part of the tumor extends through the skin an ulcerating granuloma, the size of a hen's egg.

Treatment was commenced August 18, with a daily dose of 12 grams, and was continued until October 7, with proper intervals. The steer showed no symptoms of iodism, and the tumor shrunk only slowly, while the granuloma showed no inclination to dry up. From November 9 the treatment was again commenced, and this time with better effect. The dose was increased to 15 grams. The tumor shrunk

completely, and the granuloma dried up. January 5 the treatment was discontinued, and two weeks later the steer was regarded as cured.

Post-mortem, January 27, 1893.—No traces of tumor left, except a white cicatrix in the skin. Left postpharyngeal lymph gland considerably swollen, containing several small pus centers. No internal lesions. Carcass passed as sound.

No. 130921.

Red steer, hornless; received September 5, 1892.

In right parotid region is located a fibrous tumor the size of a double-clinched fist, a similar one under the throat, the size of a child's head, and another in left parotid region, the size of a goose egg.

Treatment was commenced September 7, with a daily dose of 12 grams, and was continued until November 10, with proper intervals. The steer showed a pronounced iodism, and the tumors shrunk rapidly. When the treatment was discontinued, there only remained slight traces of the tumors, which disappeared soon afterwards.

Post-mortem, January 27, 1893.—No traces of tumors left. No internal lesions. Carcass passed as sound.

No. 39965.

Red steer, white face and stomach; received August 28, 1892.

In right parotid region is located a hard, fibrous tumor, the size of a double-clinched fist, lying loose in the connective tissue under the skin.

Treatment was commenced August 30, with a daily dose of 10 grams, and was continued until October 20, with proper intervals. By this time the tumor had almost disappeared, the steer showing a pronounced iodism. November 17 a new tumor began to form on the opposite side, and medicine was again administered until December 20, when the steer was regarded as cured.

Post-mortem, January 27, 1893.—No traces of the tumor left. No internal lesions. Carcass passed as sound.

No. 25364.

Dark red steer, horns; received September 12, 1892.

Under the throat on left side is located a hard, fibrous tumor the size of a big child's head, lying loose in the connective tissue under the skin.

Treatment was commenced September 14 with a daily dose of 12 grams and was continued until October 20. The steer showed only slight symptoms of iodism and the tumor shrank slowly. November 10 the tumor had the size of a clinched fist, and medicine was again administered until December 12, when only a small bunch was left under the skin, which disappeared soon afterwards.

Post-mortem, January 27, 1893.—No traces of the tumor left except a thick fibrous induration in the skin. No internal lesions. Carcass passed as sound.

No. 131004.

Dark-red steer, roan face, hornless; received September 5, 1892.

In sublaryngeal space is located a tumor the size of a child's head. On the lower end of this there is a granuloma about 2 inches in diameter.

Treatment was commenced on September 7 with a daily dose of 12 grams and was continued until October 7, when the granuloma had dried up and the tumor shrunk to the size of a goose egg. November 5 the granuloma began to grow again, and medicine was administered until December 12, when the steer was regarded as cured. The animal showed a pronounced iodism under the treatment.

Post-mortem, January 27, 1893.—No traces of tumor left, except a white contracted cicatrix on the slightly indurated skin. No internal lesions. Carcass passed as sound.

No. 19.

No tag. Red steer, horns.

On post-mortem examination, January 27, 1893, there was found no trace of actinomycosis, except a fibrous induration in the skin under the throat.

No. 20.

No tag. Same as above.

Both carcasses passed as sound.

No. 534833.

Dark-red steer, white forehead, hornless; received August 16, 1892.

In left parotid region, just below the ear, is located a hard, fibrous tumor the size of a hen's egg, and below this one, in the sublingual region, another the size of a child's head.

Treatment commenced August 18 with a daily dose of ten grams and was continued until October 23, with proper intervals. The steer showed a slight iodism, and when the treatment was stopped the smaller tumor had disappeared and the larger one shrunk to the size of a walnut, but covered by a very thick, fibrous induration in the skin. Medicine was therefore commenced again on November 10 and continued until December 20, with two doses per week. By this time the steer was regarded as cured.

Post-mortem, January 27, 1893.—The skin in the parotid region slightly indurated. No traces of the tumors left. No internal lesions. Carcass passed as sound.

No. 47988.

Red steer, hornless; received August 30 from Kansas City.

Flat, fibrous, bony swelling on left upper maxilla, with a granulating ulcer 3 inches in diameter.

Treatment was commenced September 1 with a daily dose of 12 grams and was continued until October 20, when the fibrous parts of the swelling had disappeared and the ulcer dried up, leaving only a small white cicatrix. November 10 this broke open again, and medicine was again administered for four weeks. The steer showed a pronounced iodism under the treatment.

Post-mortem, January 27, 1893.—The superior maxilla slightly swollen. The maxillary sinus contains a little granular tissue of a rather solid character, and not containing any pus. The lymph glands on head sound. No internal lesions. Carcass passed as sound.

No. 68060.

Red steer, white face, horns; received August 22, 1892.

In left parotid region, just below the ear, is located a hard, fibrous tumor the size of a double clinched fist. In submaxillary space is a similar one the size of a child's head.

Treatment was commenced August 24 with a daily dose of 12 grams and was continued until October 7, with proper intervals. By this time an abscess had formed in the tumor below the ear, which was opened, and a few ounces of pus evacuated, after which the tumor rapidly disappeared. As the steer got sore feet from standing on the hard floor, he was turned out, and not taken in again before October 25. By this time the tumor under the jaw had shrunk to the size of a hen's egg and medi-

cine was again administered two weeks. Shortly afterwards the steer was regarded as cured.

Post-mortem, January 27, 1893.—No traces of the tumors left. No internal lesions. Carcass passed as sound.

No. 39953.

Red steer, white star, hornless; received August 28, 1892.

In sublingual space on left side is located a fibrous tumor the size of a large child's head. The superior maxilla on same side is a little swollen.

Treatment was commenced on August 30 with a daily dose of 12 grams and was continued until October 28, with proper intervals. The steer showed only slight symptoms of iodism, but the tumor had by this time shrunk to the size of a goose egg, while the swelling on the upper jaw remained unchanged. From November 15 until December 29 medicine was again administered in doses, two or three times a week, and the remaining part of the tumor disappeared slowly.

Post-mortem, January 27, 1893.—The superior maxilla above the third molar slightly swollen. By opening the maxillary sinus is seen a bony new formation, the form and size of a cherry, extending from the socket of the molar up into the sinus. It contained granular tissue, but no pus. No traces left of the tumor under the jaw. No internal lesions. Carcass passed as sound.

No. 25.

No tag. Red steer, white star, horns.

Left lower maxilla swollen to the size of a double clinched fist.

At the post-mortem examination on January 27 the swelling proved to be spongy, filled with granular tissue and pus. In the wall of the small intestines were a few small nodules. The carcass was condemned.

No. 39968.

Black steer, white star, hornless; received August 28, 1892.

In left sublingual region is located a hard, fibrous tumor the size of a child's head.

Treatment was commenced on August 30 with a daily dose of 12 grams and was continued until October 15, with proper intervals. The steer showed a pronounced iodism, and the tumor shrunk until about one-third of its original size. From November 10 until January 15 medicine was given about twice a week, and the tumor disappeared completely.

Post-mortem, January 27, 1893.—No traces of the tumor left. A few small nodules in the wall of the small intestines. The carcass was passed as sound.

No. 39973.

Red speckled steer, horns; received August 28, 1892.

In left parotid and sublingual region is located a large, rather soft tumor the size of a cocoanut. On the left cheek there is a very hard, fibrous tumor the size of a hen's egg.

Treatment was commenced on August 30 with a daily dose of 12 grams and was continued until October 20, with proper intervals. The little, hard tumor on the cheek disappeared remarkably fast, in about two or three weeks, and the larger one also shrunk considerably, the steer showing a well-pronounced iodism. From December 5 until January 20 medicine was again administered and the tumor shrunk to the size of a hen's egg.

Post-mortem, January 27, 1893.—In left parotid region is found a fibrous induration the size of a hen's egg. It contained traces of soft tissue. No internal lesions. Carcass passed as sound.

No. 131017.

Dark red steer, horns, received September 5, 1892.

In sublaryngeal region, on the left side is located a hard, fibrous tumor, the size of a double clinched fist. On the lower end of it there is a white contracted scar, 3 to 4 inches in diameter.

Treatment was commenced September 7, with a daily dose of ten grams, and continued until October 20. The tumor shrunk to about half its original size, but the thick indurations in the skin did not improve very much. From December 5, to January 15, medicine was given every second day, and the tumor shrunk constantly but slowly.

Post-mortem, January 27, 1893.—The skin under the throat indurated and about 1 inch thick. No traces of the tumor left, no internal lesions. Carcass passed as sound.

No. 59146.

Red steer, white brisket, hornless; received August 28, 1892.

In sublaryngeal region on right side is located a fibrous tumor the size of a child's head.

Treatment was commenced August 30, with a daily dose of 12 grams, and was continued until October 15. The steer showed very little iodism, and the tumor only shrunk to about half the original size. From November 10 until January 15 medicine was given about every second day, the tumor going down slowly.

Post-mortem, January 27, 1893.—In connective tissue under the throat is located a fibrous tumor the size of a small hen's egg. It contains a few centers of soft tissue of a rather dense character. The left sublaryngeal lymph-gland swollen to about double its size, containing several small pus foci. A few small nodules in the wall of the small intestines. No other internal lesions. Carcass passed as sound.

No. 25886.

Red steer, white spot on each shoulder, horns; received September 12, 1892.

In sublaryngeal region, on right side, is located a hard, fibrous tumor the size of a cocoanut. From its lower surface depends a cylindrical granuloma, 3 inches thick, covered with thin epidermis, and 5 to 6 inches long.

Treatment was commenced on September 14, with a daily dose of 12 grams. The fibrous tumor shrunk very rapidly, but the granuloma remained almost unchanged. On November 20 the large fibrous tumor had disappeared completely, leaving the granuloma hanging loose from the skin, with no connection with the underlying tissue. It had by this time shrunk about 3 inches, and had the form and size of a goose egg, attached with the broad end to the skin, and was now of an almost fibrous character.

Post-mortem, January 27, 1893.—No notes taken about the granuloma, which has been left in the skin and overlooked. Lymph gland on head sound. No internal lesions. Carcass passed as sound.

No. 131033.

Red steer, white star, and spot on shoulder and hip, horns; received September 5, 1892.

In sublaryngeal space on right side, is located a tumor the size of a double clinched fist.

Treatment was commenced on September 7, with a dose of 10 grams, and was continued until October 15, when the tumor had disappeared. About October 25 the respiration became accompanied by a snoring sound. The breathing was *extremely difficult*, the steer's appetite failed, and it lost rapidly in flesh, and stood

with the head stretched forward, with staring eyes. Medicine was at once administered in doses of 15 grams a day, and with good success. In less than a week the respiration became almost normal, the steer regained its appetite, and soon picked up in flesh again. Above the pharynx could be felt a tumor the size of a goose egg. Medicine was then given in doses of 10 grams about every second day, and December 10th the steer was regarded as cured.

Post-mortem, January 27, 1893.—Right postpharyngeal lymph gland swollen to about three times its original size, containing a few small pus foci. No internal lesions. Carcass passed as sound.

No. 39982.

Roan steer, white brisket, hornless; received August 28, 1892.

In the loose connective tissue in the submaxillary space, are located four hard, fibrous tumors, the size of goose eggs. Two similar ones of the same size are located in the left parotid region.

Treatment was commenced on August 30, with a daily dose of 12 grams, and was continued until October 20. The steer showed no symptoms of iodism and the tumors had only shrunk a little. From November 12 the medicine was given again, and the tumors now improved faster. January 15, the steer was regarded as cured.

Post-mortem, January 27, 1893.—No traces of the tumors left. No internal lesions. Carcass passed as sound.

No. 33.

No tag, N. M. Spotted dehorned steer.

Post-mortem, January 27, 1893.—In the left parotid region was located a fibrous tumor the size of a double clinched fist. It was closely covered by the skin and contained several centers of soft granulosomatous tissue, out of which pus drops might be squeezed.

No internal lesions. Carcass condemned.

No. 39970.

Dark red steer, horns; received August 28, 1892.

In sublingual space, on right side, is located a fibrous tumor the size of a child's head, on the lower surface of which is located a granuloma 3 to 4 inches in diameter. In parotid region on same side there is a similar one, the size of a goose egg.

Treatment was commenced on August 30 with a daily dose of 12 grams and was continued until October 28, but with little success. The steer showed no symptoms of iodism, and the tumors remained almost unchanged, and the granuloma showed no tendency to dry up. Medicine was again administered from November 10 until January 15, but the tumors only shrunk to about half their original size and the granuloma became a little smaller.

Post-mortem, January 27, 1893.—In sublingual region is located a hard, fibrous tumor the size of a double clinched fist, containing numerous pockets and centers filled with soft granulosomatous tissue and pus. In parotid region a fibrous induration the size of a walnut. Lymph glands on head sound. No internal lesions. Carcass condemned.

No. 35.

No tag, N. M. Red dehorned steer, white star in forehead, stripes on shoulder, white belly.

Post-mortem, January 27, 1893.—In the sublingual region is located a fibrous induration the size of a clinched fist, containing a few centers of granulosomatous tissue, of a rather solid character, not containing pus. No internal lesions. Carcass passed as sound.

No. 39954.

Red steer, hornless; received August 28, 1892.

In left parotid region is located a hard, fibrous tumor the size of a clinched fist. It is open on the most prominent point and pus flows out. Under the throat, on the right side, is a similar tumor, the same size.

Treatment was commenced on August 30 with a daily dose of 10 grams, and was continued until October 20, when the steer was regarded as cured. The animal showed a pronounced iodism.

Post-mortem, January 27, 1893.—No traces of the tumor left. No internal lesions. Carcass passed as sound.

No. 39967.

Red steer, white star, white belly, hornless; received August 28, 1892.

In the submaxillary space are located five tumors, the largest the size of a goose egg, the smallest the size of a walnut.

Treatment was commenced on August 30, with a daily dose of 12 grams, and was continued until October 20, when the tumors had shrunk to half their original size.

From November 12 until December 30 medicine was given twice a week, and the tumors disappeared completely.

Post-mortem, January 27, 1893.—No traces of the tumors left. No internal lesions. Carcass passed as sound.

No. 39971.

Brindle steer, white forehead, horns; received August 28, 1892.

Left superior maxilla is slightly swollen and covered by an ulcer 3 inches in diameter.

Treatment was commenced on August 30, with a daily dose of 10 grams, and was continued until October 15 with proper intervals. By this time the ulcer had dried up, and only left a little contracted scar. From November 12 until January 15, medicine was given twice a week, apparently without further improvement.

Post-mortem, January 27, 1893.—The skin covering the upper maxilla a little indurated. The maxillary sinus contained an actinomycotic new formation the size of a hen's egg, but of a rather fibrous character, and not containing any pus. No internal lesions. Carcass passed as sound.

No. 40.

No tag. N. M. Red-roan, dehorned steer.

Post-mortem, January 27, 1893.—Left upper maxilla slightly swollen and covered with a layer of fibrous tissue. Small new formations in maxillary sinus. A few small nodules in wall of small intestines. Carcass passed as sound.

No. 39986.

Red steer, white face and back, hornless; received August 28, 1892.

In the intermaxillary space are located three hard, fibrous tumors the size of goose eggs.

Treatment was commenced August 30, and was continued until October 14, when all three tumors had disappeared. The steer showed a pronounced iodism and lost in condition under the treatment.

Post-mortem, January 27, 1893.—The skin covering the submaxillary space slightly indurated. Lymph glands on head sound. No internal lesions. Carcass passed as sound.

No. 25855.

Red-speckled steer, hornless; received September 12, 1892.

The sub and intermaxillary region is filled with an oblong fibrous tumor formation, closely attached to the covering skin.

Treatment was commenced September 14, with a daily dose of 12 grams, and was continued until October 25, when the swelling had almost disappeared. One of the sublingual glands could then be felt swollen to the size of a hen's egg. Medicine was given from November 10 to November 25, when the steer was regarded as cured.

Post-mortem, January 27, 1893.—No traces of the swelling left. No internal lesions. Carcass passed as sound.

No. 45879.

Red steer, hornless, white shoulders and hips; received September 5, 1892.

In sublingual region are located three distinct fibrous tumors in close connection, together the size of a cocoanut. On outside of the largest one is an ulcerating granuloma 3 inches in diameter.

Treatment was commenced on September 7 with a daily dose of 12 grams, and was continued until October 27. The steer only showed slight symptoms of iodism, but the tumors shrunk slowly, and the ulcer dried up. From November 12 until January 17 medicine was administered, and the tumors disappeared, only leaving the covering skin hard and indurated with a white contracted cicatrix thereon.

Post-mortem, January 27, 1893.—No traces of the tumors left except the induration in the skin. No internal lesions. Carcass passed as sound.

No. 44.

No tag. Red steer with white shoulders and belly.

Post-mortem, January 27, 1893.—In left parotid region is a fibrous tumor the size of a double clinched fist, almost entirely consisting of white fibrous tissue, with a few deposits of soft tissue. On the outside of it is located a dried-up granuloma, the size of a hen's egg.

The carcass was passed as sound.

No. 533794.

Red steer, white star, and white on hips; received August 22, 1892.

In left parotid region is located a hard, fibrous tumor the size of a clinched fist. From this extends a softer swelling filling the whole sublingual space, ascending on the right side up into the parotid region toward the ear.

Treatment was commenced on August 24, with a daily dose of 12 grams, and was continued until October 12. By this time the soft swelling in the sublingual space had almost disappeared, while the tumor on the left side still remained, though it had shrunk a little. From November 9 until December 20 medicine was given regularly, and from then until January 20 every second day. The tumor beneath the left ear did not disappear entirely.

Post-mortem, January 27, 1893.—In left parotid region is a fibrous tumor the size of a walnut, containing a small amount of pus. In the surrounding tissue were located a few small centers of soft tissue. In the walls of the small intestines were located a few small, hard nodules. The carcass was passed as sound.

No. 534105.

Dark-red steer, dehorned; received August 22, 1892.

In the submaxillary and sublingual space is located an immense, soft, undulating tumefaction the size of a half-peck measure. On the right cheek, outside the third molar, is a hard, fibrous tumor the size of a clinched fist.

Treatment was commenced August 24 and continued until October 25, with a daily dose of 12 grams. The steer showed a pronounced iodism and the tumefaction improved fast. By this time the tumor on the cheek had almost disappeared, while the swelling underneath was not one-third its original size. From November 11 until January 20 the medicine was given two to three times a week, and the head of the steer almost regained its normal appearance.

Post-mortem, January 27, 1893.—In the sublaryngeal space is a soft, fibrous induration containing a number of small fibrous nodules, varying in size from a pea to a bean, containing no pus, but a small amount of soft tissue. Lymph glands on head sound. No internal lesions. Carcass passed as sound.

No. 131038.

Brown steer, horns; received September 5, 1892.

In right parotid region is located a hard, fibrous tumor, the size of a double clinched fist.

Treatment was commenced on September 7, with a daily dose of 10 grams, and continued until October 25, with proper intervals. The steer showed a pronounced iodism and the tumor disappeared altogether.

Post-mortem, January 27, 1893.—No traces of the tumor left. Lymph glands on head sound. No internal lesions. Carcass passed as sound.

No. 45973.

Black steer, speckled back and breast, dehorned; received September 5, 1892.

In left parotid region is located a hard, fibrous tumor the size of a goose egg. A similar one the size of a child's head is located in the submaxillary space.

Treatment was commenced on September 7, with a daily dose of 12 grams, and continued until October 22. The steer showed a pronounced iodism, and the tumors shrunk fast. From November 9 until December 20 medicine was again administered, and both tumors disappeared completely.

Post-mortem, January 27, 1893.—No traces of the tumors left except a slight induration in the skin. Lymph glands on head sound. No internal lesions. Carcass passed as sound.

No. 45909.

Dark-red steer, white star and spot on shoulders, ears cut; received September 5, 1892.

In sublaryngeal and submaxillary space is located a large, fibrous tumor, on the lower surface of which is located an ulcerating granuloma, 6 to 7 inches in diameter.

Treatment was commenced on September 7, with a daily dose of 12 grams, and continued until October 20. The steer showed a pronounced iodism, and the fibrous parts of the tumor shrunk and contracted so fast that a large piece of the granuloma was expelled, and the rest dried up and disappeared, leaving a white contracted scar. Medicine was again administered from November 10 until January 20, when the tumefaction had disappeared, only leaving the skin hard and indurated.

Post-mortem, January 27, 1893.—No traces of the tumor left, except a fibrous induration in the skin showing traces of soft tissue. No internal lesions. Carcass passed as sound.

No. 40733.

Brown bull, horns; received August 30, 1892, from Kansas City.

In the submaxillary space on the right side is located a hard, fibrous tumor the size of a child's head. On the right cheek is a similar one the size of a goose egg.

Treatment was commenced September 1 by a daily dose of 12 grams, and continued until December 25, with proper intervals. The steer showed a pronounced iodism, and the tumor on the cheek disappeared fast, while the larger one shrunk considerably. From November 10 until December 28 medicine was again administered, and the remaining tumor disappeared slowly, leaving the skin indurated.

Post-mortem, January 27, 1893.—No traces of the tumors left. Lymph glands on head sound. In the wall of the small intestines were found located a few small, hard nodules. Carcass passed as sound.

No. 131063.

Black steer, horns, ears cut; received September 5, 1892.

In sublingual space is located a hard, fibrous tumor the size of a child's head.

Treatment was commenced on September 7, with a daily dose of 10 grams, and continued until October 22, when the tumor had almost disappeared. The steer showed a pronounced iodism.

Post-mortem, January 27, 1893.—No traces of the tumor left, except a fibrous induration in the skin. Lymph glands on head sound. No internal lesions. Carcass passed as sound.

No. 45932.

Roan bull, hornless; received September 5, 1892.

In the loose connective tissue under the skin covering the sublingual region on the left side is located a tumor the size of a double clinched fist. It is hard and fibrous, with a smooth surface. On the lower end there is a scar, and here the skin is in close connection with the tumor.

The treatment was commenced September 6 by giving a dose of 15 grams iodide of potassium daily, with proper intervals of about one or two days a week. The medicine did not have any marked effect on the bull, which only showed vague symptoms of iodism, the tumor shrinking but slowly. At the end of the fourth week the treatment was stopped, the tumor having then shrunk to about one-third its original size. In less than three weeks the rest disappeared without any further treatment, leaving only a hard fibrous thickening in the skin, the size of the palm of a hand, which made it look as if there was still a tumor there, but by manipulation no traces of the original lump can be detected.

Post-mortem, January 27, 1893.—The skin covering the left parotid region a little indurated, and covered by a white scar. Lymph glands on head sound. On surface of liver a small nodule the size of a bean. Carcass passed as sound.

No. 53.

No tag; red hornless steer, white belly, white spot on left side.

Post-mortem, January 27, 1893.—No lesions of any kind found. Carcass passed as sound.

No. 39990.

Roan dehorned heifer; received August 28, 1892.

In the submaxillary space is located a hard, fibrous tumor the size of a large coconut.

Treatment was commenced August 30, with a daily dose of 10 grams, and was continued until October 25, with proper intervals. The heifer showed no symptoms of iodism, and the medicine had hardly any effect on the tumor. The treatment was continued from 9th of November until January 25, but without success. The tumor only shrunk a little.

Post-mortem, January 27, 1893.—In left side of the submaxillary space was located a hard, fibrous tumor the size of a child's head, containing several centers of soft granulatous tissue and pus. No internal lesions. The carcass was condemned.

No. 531549.

Red steer, hornless; received August 22, 1892.

In the sublaryngeal space on the left side is located a hard, fibrous tumor the size of a double clinched fist.

Treatment was commenced on August 24, with a daily dose of 12 grams, and was continued until October 15, when the tumor had disappeared. The steer showed a pronounced iodism.

Post-mortem, January 27, 1893.—No traces of the tumor left. No internal lesions. The carcass was passed as sound.

No. 45930.

Red bull, hornless; received September 5, 1892.

In sublaryngeal space on left side is located a hard, fibrous tumor the size of a child's head, lying loose in the connective tissue under the skin.

Treatment was commenced on September 7, with a daily dose of 12 grams, and was continued until October 20, when the tumor had shrunk to the size of a clinched fist. From November 10 until December 20 medicine was again administered and the rest of the tumor disappeared.

Post-mortem, January 27, 1893.—No traces of the lump left. No internal lesions. Carcass was passed as sound.

No. 59131.

White steer, hornless; received August 30, 1892, from Kansas City.

The left upper maxilla is slightly swollen. In sublaryngeal space on left side is located a hard, fibrous tumor the size of a cocoanut.

Treatment was commenced September 1, with a daily dose of 12 grams, and was continued until October 20, when the soft tumor had almost disappeared, while the bony swelling remained the same. The treatment was continued from November 10 to January 20. The steer showed a pronounced iodism, and the tumor underneath disappeared completely.

Post-mortem, January 27, 1893.—The left upper maxilla is swollen slightly. The maxillary sinus was completely filled with actinomycotic new formations extending into the nasal fossa. The three first molars were pushed slightly outward. Lymph glands on head sound. No internal lesions. Carcass condemned.

No. 39962.

Red heifer, white belly; received August 28, 1892.

In left sublaryngeal space is located a tumor the size of a double clinched fist.

Treatment was commenced on August 30, with a daily dose of 10 grams and continued until October 10, when the heifer was cured.

Post-mortem, January 27, 1893.—No traces of the tumor left, no internal lesions. Carcass was passed as sound.

No. 40000.

Red cow, hornless; received August 23, 1892.

In left parotid region is located a large, rather soft tumor, extending from the ear down into the sublaryngeal region.

Treatment was commenced on August 24, with a daily dose of 10 grams and continued until October 27, when the whole tumor had disappeared, except a fibrous induration in the skin.

Post-mortem, January 27, 1893.—No traces of the tumor left except a fibrous induration in the skin. No internal lesions. Carcass passed as sound.

No. 45927.

Brindle steer, white star, hornless; received September 5, 1892.

In sublaryngeal space is located a fibrous tumor the size of a cocoanut, and a similar one the size of a goose egg in the intermaxillary space.

Treatment was commenced on September 7, with a daily dose of 10 grams, and continued until October 10. The steer showed a pronounced iodism, and the tumors shrunk considerably. From November 12 until December 20, medicine was again administered, and the tumors disappeared completely.

Post-mortem, January 27, 1893.—No traces of the tumors left except an induration in the skin. No internal lesions. Carcass was passed as sound.

No. 39996.

Red bull, dehorned; received August 28, 1892.

In sublaryngeal space is located a fibrous tumor the size of a child's head. On the inside of the lips are located a few small granulomas.

Treatment was commenced on August 30, with a daily dose of 12 grams, and continued until October 25. The bull showed hardly any symptoms of iodism, and the tumor shrunk but slowly. The granulomas on the lips disappeared after two weeks' treatment. Medicine was given from November 10 until December 20, when most of the tumor had gone.

Post-mortem, January 27, 1893.—No traces of tumors left, except a fibrous induration in the skin. No internal lesions. The carcass was passed as sound.

No. 62.

No tag. Red steer, hornless, white face and neck.

Post-mortem, January 27, 1893.—No traces of actinomycosis found. The carcass was passed as sound.

No. 45918.

Speckled steer, red head and neck, hornless; received September 5, 1892.

In sublaryngeal space is located a fibrous tumor the size of a cocoanut. On the lower surface is located an ulcer, from 5 to 6 inches in diameter.

Treatment was commenced September 7 with a daily dose of 12 grams and continued until October 20, with proper intervals. The steer showed a well-pronounced iodism, and the ulcer soon dried up and shrunk. From November 10 until January 20 medicine was again administered and the tumor disappeared entirely, leaving a hard, fibrous induration in the skin, covered by a white scar.

Post-mortem, January 27, 1893.—No traces of the tumor left, except the induration in the skin. In sublingual gland a granuloma the size of a walnut, not containing any pus. No internal lesions. Carcass passed as sound.

No. 64.

No tag. Black, dehorned steer.

Post-mortem, January 27, 1893.—In submaxillary space a fibrous induration 2 inches thick, showing traces of soft tissue. Lymph glands on head sound. No internal lesions. Carcass passed as sound.

No. 65.

No tag. Red steer, horns, white face.

Post-mortem, January 27, 1893.—On left lower maxilla was a bony tumor the size of a double clinched fist. The internal parts of the tumor were spongy, and contained numerous cavities filled with soft granulomatous tissue and pus. No internal lesions. Carcass condemned.

No. 48140.

Red steer, white star, hornless; received August 30, 1892, from Kansas City.

In right upper maxilla is a fibrous enlargement the size of a clinched fist. On the most prominent point is located a small ulcer 1 to 2 inches in diameter.

Treatment was commenced on September 1, and continued until October 20, when the fibrous points of the tumor had shrunk and the ulcer dried up. The treatment was continued from November 10 until January 20, with doses twice a week.

Post-mortem, January 27, 1893.—The swelling on the right upper maxilla is covered by a thin layer of fibrous tissue, inclosing a few small centers of soft tissue containing pus. The maxillary sinus is completely filled by actinomycotic new formations, extending into the nasal fossa. Lymph glands on head sound. No internal lesions. Carcass condemned.

No. 44534.

Red steer, large horns; received September 12, 1892.

In right parotid region are located three tumors the size of goose eggs, a similar one the size of a cocoanut in sublingual region, and two the size of goose eggs in left parotid region.

Treatment was commenced on September 14 with a daily dose of 12 grams, and continued until October 25. October 2 two abscesses were formed in right parotid region. The steer showed a pronounced iodism and all the tumors shrunk considerably.

From November 12 medicine was again administered, and the tumors disappeared, leaving only a fibrous induration in the skin.

Post-mortem, January 27, 1893.—No traces of tumors left. Lymph glands on head sound. Mesenteric glands swollen to the size of hen's eggs containing pus (probably not actinomycotic). Numerous small abscesses in both lungs. Carcass condemned.

No. 45969.

Red steer, white star and rump; dehorned; received September 5, 1892.

In left parotid region were located two tumors the size of hen's eggs. Three similar ones the size of goose eggs in intermaxillary space.

Treatment was commenced on September 7 with a daily dose of 10 grams, and continued until September 29, when the steer was almost cured. It showed a pronounced iodism.

Post-mortem, January 27, 1893.—No traces of tumors left. In liver an abscess the size of a hazelnut. Carcass passed as sound.

No. 69.

No tag. Speckled steer, horns.

Post-mortem, January 27, 1893.—All the left side of the face immensely swollen from the eye down to the nose. The bony swelling covered by a thin layer of fibrous tissue. The maxillary sinus is filled with granulomatous tissue, and the bordering bones are rarefied. The actinomycotic new formations extend into the nasal fossa almost down to the nostril. The carcass was condemned.

No. 541268.

Strawberry roan steer, dehorned; received August 16, 1892.

On the right cheek are located three hard tumors the size of walnuts. In submaxillary space is a tumor the size of a child's head.

Treatment was commenced August 17, with a daily dose of 10 grams. On August 22, there appeared suddenly a granulomatous growth in the middle of the forehead, and another one behind the crest of the occiput. They were both round, 2 inches in diameter, red, and blood-filled, and looked like a large strawberry. The dose of medicine was increased to 12 grams a day, and in less than a week they had both completely disappeared. The treatment was continued until October 12, when all the tumors had disappeared.

Post-mortem, January 27, 1893.—No traces of tumors left. No internal lesions. Carcass passed as sound.

No. 45896.

Red steer, speckled side and back; received September 5, 1892.

In left parotid region and sublingual space is located a rather soft tumor the size of a child's head.

Treatment was commenced on September 7 and continued until October 22, with a daily dose of 12 grams. The steer showed a pronounced iodism, and the tumor shrunk fast. From November 10 until December 15 medicine was again administered, and soon afterwards the tumor had disappeared completely.

Post-mortem, January 27, 1893.—No traces of tumor left. Sublingual lymph glands indurated and swollen to the size of a walnut, containing a few drops of pus. No internal lesions. Carcass passed as sound.

No. 45942.

Brown steer, hornless; received September 5, 1892.

In sublingual region on left side is located a hard, fibrous tumor, the size of a large coconut. On lower surface there is an ulcerating granuloma 4 to 5 inches in diameter.

Treatment was commenced on September 7, with a daily dose of 12 grams, and continued until October 25. The steer showed hardly any symptoms of iodism, and the tumefaction only improved slowly. Medicine was again administered from November 10 until January 20, but the tumor only shrunk to about half the original size, and the granuloma grew a good deal smaller, without showing any tendency to dry up.

Post-mortem, January 27, 1893.—The parotid glands on both sides swollen and containing several pus-foci. In sublingual space is located a fibrous tumor, the size of a child's head, containing one big pus cavity, and several small centers of soft tissue and pus. In both lungs were numerous small abscesses.

The carcass was condemned.

No. 73.

No tag. Dark red steer, horns.

Post-mortem, January 27, 1893.—On right lower maxilla is a bony swelling the size of a clinched fist. The internal parts of the tumor were spongy, and contained a quantity of soft tissue and pus.

The carcass was condemned.

No. 74.

No tag. Dark red bull, horns.

Post-mortem, January 27, 1893.—In submaxillary space is a small fibrous induration in the skin. No traces of soft tissue. No internal lesions. Carcass passed as sound.

No. 75.

No tag. Red steer, hornless, white star, belly and flank.

Post-mortem, January 27, 1893.—On right lower maxilla is a bony enlargement the size of a hen's egg. The internal parts were rather compact and only spongy in the center, where a small amount of granulomatous tissue was present. No internal lesions. Carcass passed as sound.

No. 33956.

Speckled steer, hornless; received August 28, 1892.

In submaxillary space are located three hard fibrous tumors, the size of a goose egg, loose in connective tissue under the skin. On right cheek a similar one, the size of a hen's egg.

Treatment was commenced on August 30, with a daily dose of 12 grams, and continued until October 20. The steer showed a pronounced iodism, and the tumors disappeared completely.

Post-mortem, January 27, 1893.—Small fibrous indurations in the skin in submaxillary space. Large contracted scar on anterior surface of liver. Carcass passed as sound.

No. 77.

No tag. Spotted steer, horns.

Post-mortem, January 27, 1893.—On left lower maxilla is a bony tumor the size of a double clinched fist. It is covered by a thick layer of fibrous tissue, containing several centers of soft tissue. The internal parts of the tumor were spongy, the cavities filled with soft tissue and pus. No internal lesions. Carcass condemned.

No. 545789.

Red steer, speckled on head, brisket, belly, and legs; received August 16, 1892.

All the left side of the face from eye to nostril considerably swollen. Three inches below the eye is located an ulcer 4 to 5 inches in diameter. The swelling is hard and supposed to be bony in the deeper parts.

Treatment was commenced on August 18 with a daily dose of 10 grams, and continued until October 7, when the ulcer had healed up completely and the swelling had been reduced to the size of a goose egg. No more medicine was given until November 10, and the swelling improved slowly, and it was therefore concluded that it did not extend into the maxillary sinus. From November 10 until January 20 medicine was given about twice a week and the swelling shrunk so that it was hardly noticeable.

Post-mortem, January 27, 1893.—The left upper maxilla a little swollen, covered by a thin layer of fibrous tissue, not containing any soft tissue. The bone itself is a little rarefied, but the lesion does not extend into the sinus. The infection has probably taken place through some external abrasion in the skin. The lymph glands on head sound. No internal lesions. The carcass was passed as sound.

No. 59092.

Brindle heifer, white face and back, dehorned; received August 28, 1892.

In submaxillary space are located three fibrous tumors, the size from a child's head to a goose egg, closely connected with each other.

Treatment was commenced on August 30 with a daily dose of 10 grams and continued until October 25, when there only remained one tumor the size of a goose egg. The heifer showed a pronounced iodism. From November 10 until December 15 medicine was again administered, when the heifer was regarded as cured.

Post-mortem, January 27, 1893.—No traces of the tumors left. Lymph glands on head sound. No internal lesions except a cysticercus bovis in the liver. Carcass passed as sound.

No. 252388.

Red steer, white on left flank and belly, white forehead; received July 25, 1892.

Condition very poor. The left lower maxilla is immensely swollen from the angle of the jaw to the chin. The swelling extends up over the cheek towards the eye and is of a very dense, fibrous character, on some places almost bony. On the lower surface are located two ulcerating granulomas, one smaller, about 2 inches in diameter, and a larger one, 5 or 6 inches in diameter. The surface of the granulomas is raw, covered with pus crusts. In the parotid region on the same side are located two round, hard tumors, one just below the ear the size of a hen's egg, and below this another the size of a clinched fist. The deformation of the lower maxilla has interfered with the mastication in a considerable degree, so the steer is only able to eat soft or ground feed, but no hay. When not eating he is grinding his teeth and the saliva flows incessantly from his mouth. The steer is very weak, lies down almost all day, and looks as if he were not able to live until the next day. The excretion from the ulcers is exceedingly fetid.

Treatment.—From July 27 until August 1, 5 grams of iodide of potassium dissolved in 15 grams of water were injected into the jugular vein. It had to be stopped, as phlebitis resulted. The three following days the same amount was injected hypodermically on the neck, but this caused mortification of the tissue at the place of injection. Nevertheless, it had a good effect, and the granulomas began to dry up at the edge. From August 4 the medicine was given internally in doses of 10 grams daily, which was continued until October 25, when the steer was cured. The little granuloma had disappeared completely, while the large one had been reduced to a scar in the skin the size of a silver dollar. The fibrous swelling was reduced to a small induration in the skin on the cheek. The steer ate and drank all he was given, and became fat. The two tumors in the parotid region became fluctuating, were opened with a knife, and a few ounces of good pus evacuated, after which they disappeared completely. During the treatment the ulcers had been washed with a 2 per cent creolin solution to prevent the smell and dusted with equal parts of iodoform and boric acid. When they had dried up they were painted with tincture of iodide.

Post-mortem, January 27, 1893.—Under the skin of the left cheek is a small fibrous induration, and outside a white scar the size of a silver half dollar. Of the tumors in parotid region no traces are left. No internal lesions. Carcass passed as sound.

No. 159687.

Light red steer, dehorned; received July 25, 1892.

The right upper maxilla swollen to the size of a clinched fist. The swelling is bony and closely covered by the skin, and on the lower end of it is a small scar where the skin has been broken. On the inside of the upper lips are located two flat granulomas, one to two inches in diameter.

Treatment was commenced July 27 with a daily dose of 10 grams. The swelling began to grow right away, so it was evident that the maxillary sinus was filled with new formations. August 1, the scar on the point of the swelling broke open and a few drops of the pus were discharged. The tumor kept on growing until August 15, when it began to decrease. The scar healed up and about the middle of September the tumor had regained its original size. By this time the maxilla on the opposite side began to swell. It had from the beginning been slightly swollen, but so little that it was hardly noticeable. In spite of increased and frequent doses of medicine, it increased rapidly in size. This is the only case where the medicine did not at least stop the progress of the disease. The treatment was continued until the ani-

mal was killed, by which time the tumor on the right side had its original size, and the one on the left side was about the size of a small hen's egg. An external treatment with unguentum iodi had no effect.

Post-mortem, January 27, 1893.—The maxillary sinus on both sides filled with actinomycotic new formations. The bony swelling is on the outside covered by a thin layer of fibrous tissue containing a few centers of soft tissue. No internal lesions. The carcass was condemned.

No. 252388.

Red steer, white on left flank and belly, white forehead; received July 25, 1892.

The left lower maxilla is immensely swollen from the chin to the angle of the jaw. The swelling is of a fibrous character, but seems to be bony in the deeper parts. The surface is covered by two ulcerating granulomas, the smaller one $1\frac{1}{4}$ inches in diameter, and the larger one almost circular, 5 to 6 inches in diameter. The granulomas are partly covered with dried pus, and are partly raw and bleeding. In the parotid region on the same side is located two tumors, one just below the ear and the size of a hen's egg, and below this another the size of a clinched fist. Both of these tumors were slightly fluctuating. The deformation of the lower maxilla has interfered considerably with the mastication, so the steer is only able to eat soft or ground feed, but no hay. When not eating he is constantly grinding his teeth, and the saliva flows incessantly from his mouth. The steer is in very poor condition, lies down most of the time, and looks as if he had not many more days to live.

The treatment was commenced July 27 with a dose of 10 grams of iodide of potassium. The three following days a solution of 5 grams of iodide of potassium in 15 grams of distilled water was injected into the jugular vein, but had to be stopped, as there resulted phlebitis. The same treatment was then tried hypodermically, the solution being made a little weaker (1-4), but this resulted in a necrosis of the tissue at the place of injection. The treatment was therefore continued by giving the medicine internally until the 1st of September. The steer showed pronounced iodism, the granulomas dried up and shrunk, and the whole tumefaction was reduced to less than one-third its original size. The ulcers, which in the beginning were exceedingly fetid, were washed in a 2-per cent solution of creolin and dusted with iodoform and boracic acid, equal parts. The two tumors in the parotid region had been opened with a knife and a small amount of pus evacuated. From September 15 till October 15 medicine was again administered and the tumor on the jaw was reduced to a small fibrous induration in the skin, covered by a pink cicatrix, the size of a silver dollar. The two tumors in the parotid region disappeared completely. The lesion did not extend into the bony tissues of the lower maxilla as was at first supposed. About November 1 the steer was regarded as cured and was in splendid condition.

Post-mortem, January 29, 1893.—On the left cheek and in left parotid region is a slight fibrous induration of the skin. No traces of soft tissue left. No internal lesions. Carcass passed as sound.

No. 159687.

Light red steer, hornless; white forehead, white marks on belly, flank, and legs; received July 25, 1892.

On the right upper maxilla is located a swelling the size of a large goose egg, about 5 inches long and $3\frac{1}{2}$ inches wide. The swelling is bony, hard, and closely covered by the skin. On the lower end of it is located a small scar, where the skin has been broken, but now is healed up. The left upper maxilla is slightly swollen, hardly noticeable. On the inside of the upper lip is located two small flat actinomycomas $1\frac{1}{2}$ to 2 inches in diameter. The steer is in fairly good condition.

The treatment was commenced July 27, 1892, with a daily dose of 10 grams. August 1 the swelling had apparently increased a little, and the scar on the lower

end broke open and a few drops of pus was discharged. For the first two weeks the tumor increased in size slowly, in spite of the increase in the dose to 12 to 15 grams a day. Then it commenced to shrink again, until it had reached the original size. About September 1 the upper maxilla on the left side began to swell, regardless of the large doses of medicine. This is the only case out of 192 animals affected with actinomycosis where the medicine did not at least arrest the progress of the disease, but the steer showed a perfect insusceptibility to the effect of the treatment. The administration of medicine was continued with proper intervals until the steer was slaughtered, by which time both tumors were about the same size, the one on the right side a little larger than originally. The two granulomas inside the upper lip disappeared after three to four weeks' treatment. An external application of iodine ointment to the tumors had no effect.

Post-mortem, January 29, 1893.—The maxillary sinuses on both sides completely filled with soft actinomycotic new formations, extending into the nasal fossa. Infection has evidently taken place through the dental alveoli of the third molar on both sides, as they were pushed slightly out of their places. The lymph glands on the head were sound. No internal lesions. Carcass condemned.

No. 596938.

Red steer, white forehead, rudiments of horns; received July 30, 1892.

In the sublingual region is located a hard, fibrous tumor, the size of a double clinched fist, lying loose in the connective tissue under the skin. From the lower surface of the tumor projects a round, red granuloma about 4 inches in diameter.

Treatment was commenced August 1 with a daily dose of 12 grams and was continued until January 20, 1893. The steer showed no symptoms of iodism and the tumor improved only slowly. About October 1 the tumor had shrunk to half its original size and the granuloma had dried up and shrunk to the size of a silver dollar. By this time an abscess formed in the left parotid region just below the ear, which broke open, and a small amount of pus was evacuated. The tumor kept on shrinking slowly and had almost disappeared when the animal was slaughtered.

Post-mortem, January 29, 1893.—In the sublingual region is a fibrous induration in the skin about 1 inch thick, on the outside of which is located a white contracted cicatrix. In the left parotid region is a small induration in the skin. The lymph glands on the head were sound. In the upper part of the left lung was located an actinomycotic tumor the size of a child's head. The carcass was condemned.

No. 596939.

Red stag, horns; received July 30, 1892.

In the right parotid region is located a fat, hard fibrous tumor, the size of the palm of the hand. It is closely connected with the covering skin. In the center of the swelling is an open scar, out of which flow a few drops of yellow pus. In the sublingual space, on the right side, is located a hard fibrous tumor, the size of a goose egg, lying loose in the connective tissue under the skin. On the lower end of it is a small scar where it has been broken and from the skin it is thus connected with the tumor. On the inside of the right cheek, inside the third molar, is located a red granuloma the size of a silver dollar. The surface is breaking up and covered with pus crusts. The surrounding skin is hard and indurated. On the inside of the upper lip is located a small round granuloma the size of a silver dollar and as wide.

Treatment was commenced August 1 with a daily dose of 12 grams and was continued until October 25 with proper intervals. The stag showed a general iodism and the tumors improved rapidly. The granuloma on the inside disappeared after two weeks' treatment. The one on the lower end of the lip disappeared after four weeks' treatment, and the last swelling in the parotid region vanished with each

disappeared. From November 1 until November 15 medicine was again administered, and shortly afterwards the stag was regarded as cured.

Post-mortem, January 29, 1893.—No traces of the tumors left. No internal lesions. Carcass passed as sound.

No. 294924.

White steer, horns; received July 30, 1892.

In the sublingual space on the right side is located a hard, fibrous tumor, the size of a double clinched fist, lying loose in the connective tissue under the skin.

On the left shoulder is located a red, soft granuloma the size of a large hen's egg. The surrounding skin is thick and indurated, but is not connected with the underlying tissue.

Treatment was commenced August 1 with a daily dose of 10 grams and was continued until September 12, when the tumor in the sublingual space had disappeared and the granuloma on the shoulder had shrunk to the size of a hazelnut. From September 20 to September 30 medicine was again administered and the steer was regarded as cured.

Post-mortem, January 29, 1893.—No traces of the tumors left; no internal lesions. Carcass passed as sound.

No. 322415.

Dark-red steer, horns; received July 25, 1892.

Both the lower maxillas, especially the left one, are immensely swollen from the chin to the neck. The swelling extends up over the left side of the face toward the eye. On the lower surface is located an ulcerating granuloma, 6 inches in diameter, and protruding 4 to 5 inches over the swollen edges of the surrounding tissue. The whole tumefaction is the size of a half-peck measure. The teeth in the left lower maxilla are pushed out of their sockets, so that mastication is considerably impaired.

Treatment was commenced July 27 with a daily dose of 10 grams and was continued until January 25, 1893, with proper intervals, some of these extending over two to three weeks. The steer showed no symptoms of iodism whatever, even if the doses were increased to 15 grams per day and continued for two weeks without stopping; consequently the effect on the tumor was very little. The granuloma did not dry up after the treatment had been continued for three months, and neither this nor the fibrous tumor became smaller. Injections into the granuloma of a concentrated solution of iodide of potassium or of tincture of iodine only produced a small abscess at the place of injection, which would break open and a small amount of pus be evacuated. In spite of the daily doses of medicine the steer, which was rather poor at first, put on flesh and became fat.

Post-mortem, January 29, 1893.—The granuloma was covered with a thin layer of epidermis, and was not soft, but had become of a more fibrous character. A section through it proved it to consist of a stroma of fibrous tissue in which were embedded the larger and smaller centers of granular tissue. This is of a dense character and does not contain pus. The surrounding parts of the tumefaction consisted of soft, white, fibrous tissue, with no traces of soft tissue. The lower maxilla was considerably swollen, the inner parts being spongy and containing numerous centers of soft tissue, but no pus. The lymph glands on the head were sound. No internal lesions. Carcass condemned.



252388

BEFORE TREATMENT—AFTERWARD CURED.



373406

BEFORE TREATMENT—AFTERWARD CURED.



545764

BEFORE TREATMENT—AFTERWARD CURED.



45932

BEFORE TREATMENT—AFTERWARD CURED.



45982

BEFORE TREATMENT—AFTERWARD CURED.



534819

ANIMAL TREATED, BUT NOT CURED.





545512

BEFORE TREATMENT—AFTERWARD CURED.



39963

BEFORE TREATMENT—AFTERWARD CURED.



534024

BEFORE TREATMENT—AFTERWARD CURED.



545801.

BEFORE TREATMENT—AFTERWARD CURED.



39976

BEFORE TREATMENT—AFTERWARD CURED.



545524

ANIMAL TREATED, BUT NOT CURED.



533796

BEFORE TREATMENT—AFTERWARD CURED.



545523

BEFORE TREATMENT—AFTERWARD CURED.



130915

ANIMAL TREATED, BUT NOT CURED.



499857

BEFORE TREATMENT—AFTERWARD CURED.





U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF ANIMAL INDUSTRY.

BULLETIN No. 3.

MISCELLANEOUS INVESTIGATIONS

CONCERNING

INFECTIOUS AND PARASITIC DISEASES

OF

DOMESTICATED ANIMALS.

CONDUCTED UNDER THE DIRECTION OF DR. D. E. SALMON,
CHIEF OF THE BUREAU OF ANIMAL INDUSTRY,

BY

F. L. KILDORNE, VERANUS A. MOORE, E. C. SCHROEDER,
THEOBALD SMITH, AND C. W. STILES.

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MISCELLANEOUS INVESTIGATIONS

CONCERNING

INFECTIOUS AND PARASITIC DISEASES

OF

DOMESTICATED ANIMALS.

CONDUCTED UNDER THE DIRECTION OF DR. D. E. SALMON,
CHIEF OF THE BUREAU OF ANIMAL INDUSTRY,

BY

F. L. KILBORNE, VERANUS A. MOORE, E. C. SCHROEDER,
THEOBALD SMITH, AND C. W. STILES.

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LETTER OF TRANSMITTAL

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., August 29, 1893.

SIR: I have the honor to herewith transmit the results of some important investigations concerning infectious and parasitic diseases, as revealed by researches made by my assistants in the laboratory and at the Experimental Station of the Bureau while engaged in efforts to determine the causes of some of the more destructive communicable and contagious diseases of domesticated animals.

Very respectfully,

D. E. SALMON,
Chief of Bureau.

HON. J. STERLING MORTON,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., April 25, 1893.

SIR: I have the honor to submit herewith some investigations concerning infectious and parasitic diseases of domesticated animals, which are either the outgrowth of more important researches already published or else fragments of such work under way. The slow progress made, largely due to the want of suitable material for investigation, makes it very desirable that integral portions of our work be not withheld too long from publication, provided premature conclusions are not drawn therefrom. The minor investigations herewith presented are all of them important in aiding our understanding of infectious animal diseases, and in paving the way for their control or suppression.

Very respectfully,

THEOBALD SMITH,
Chief of the Division of Animal Pathology.

Dr. D. E. SALMON,
Chief of the Bureau of Animal Industry.

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MISCELLANEOUS INVESTIGATIONS CONCERNING INFECTIOUS AND PARASITIC DISEASES OF DOMESTICATED ANIMALS.

OBSERVATIONS ON THE MORPHOLOGY, BIOLOGY, AND PATHOGENIC PROPERTIES OF TWENTY-EIGHT STREPTOCOCCI FOUND IN THE INVESTIGATION OF ANIMAL DISEASES.

By VERANUS A. MOORE.

In the bacteriological investigation of diseased animal tissues which has been carried on in this laboratory, streptococci have frequently been found, either alone or associated with other bacteria. Their occasional appearance in greater or less numbers in the variously affected organs, more especially when associated with those morbid conditions which could not be attributed to any specific cause, suggested the desirability of determining as far as possible the relations existing between the streptococci and the lesions in which they were found. The results that had been obtained, and the observations that had been made by a few investigators with reference to the etiological value of certain streptococci, gave hope that with a better knowledge of this group of bacteria the cause of a greater or less number of morbid conditions might be explained. Since the summer of 1888, therefore, the streptococci that have appeared in the regular examinations in this laboratory have for the greater part been isolated and subjected to a somewhat thorough investigation with reference to their morphology, biology, and especially their pathogenic properties. It should be stated that several of the streptococci that had appeared prior to this time had been quite carefully studied, but no attempt had been made to isolate and compare all of these forms. My work upon this group of bacteria has been done under the direction of Dr. Theobald Smith, Director of the Laboratory, to whom I am indebted for valuable suggestions and assistance in the isolation of many of these streptococci. For the inoculation of pigs and the careful watching of the same subsequently, I am indebted to Dr. F. L. Kilborne. Other and more important work has necessarily confined this study within quite narrow limits, and prevented the carrying out of extended experiments in any of the many directions suggested by these preliminary observations.

Since Billroth called attention to this group of bacteria, much has been written concerning the streptococci that have been found to be associated with lesions in a large number of diseases in both man and the lower animals. A few of these streptococci have been found by careful study and investigation to be of specific etiological value, but a considerable number of them, on account of their frequent appearance and their pathogenic effect on certain of the experimental animals, have been considered as bearing a more or less causal relation to the lesions with which they were associated. While it is my purpose to present simply the results of the observations made on the streptococci examined, a brief mention of the more important work that has been done on this subject, and from which many suggestions have been obtained, should not be omitted.

Koch found in putrid fluids a streptococcus which, when inoculated into the ear of a mouse, produced necrosis of the surrounding tissue, destruction of the cartilage cells, and death of the animal in about three days.

In the earlier investigations of swine diseases carried on by the U. S. Department of Agriculture, Dr. Salmon isolated micrococci from the diseased organs of pigs. The micrococci grew in shorter or longer chains, and in stained cover-glass preparations they exhibited a light center. These forms were so constantly present that they were supposed to have a more or less causal relation to the diseases with which they were associated.

Klein, in his investigation of a cattle disease known as "cow scarlatina," or the "Hendon cow disease," found a streptococcus in the sores on the udders of the diseased cows. He isolated and carefully studied this streptococcus. When it was inoculated into calves and mice it produced a definite disease, which he considered to be identical with the disease that was produced by the scarlatina streptococcus. In another outbreak, which manifested itself by a contagious, ulcerative process on the teats and udders of certain cows which furnished milk to the Edinburgh dairy, other streptococci were obtained, one of which Klein considered as standing in some "necessary relation to the disease."

The same author, in his investigations of "foot-and-mouth disease" in sheep, concludes that the cause of the disease is a micrococcus, which grew in chains. He obtained the germ from cultures made from the lymph of a sheep which was affected with the disease. Inoculation experiments with this germ were negative, but by feeding sheep with cultures of the twentieth generation the typical disease was produced. From the vesicles of the artificially-produced disease pure cultures of the micrococcus were obtained.

Sand and Jensen in 1887 investigated the cause of strangles in horses. In 29 cases they invariably found in the pus from the suppurating glands and in the nasal discharge a characteristic streptococcus.

It grew on all of the ordinary culture media. It destroyed mice, and two of the three rabbits that were inoculated with it in the veins died. Guinea-pigs were immune. Horses were not affected, but colts developed typical strangles after spraying the nasal mucous membrane with a bouillon culture of the streptococcus. One of these died. Two colts that were inoculated intravenously suffered from phlebitis and abscesses, after which they were immune.

Schütz found a streptococcus in the pus from the glands of horses suffering from strangles. It was fatal to mice, but rabbits, guinea-pigs, and pigeons were immune. The nasal cavities of a colt, 6 to 8 weeks old, were sprayed several times with a pure bouillon culture of this germ. It died of strangles on the 23d day. Schütz examined the pus from the suppurating glands of a considerable number of horses suffering from strangles, in all of which he found the streptococcus. Zschokke, in 1886, found a streptococcus in horses suffering from strangles, but supposed it, prior to Schütz's investigations, to be identical with *Streptococcus pyogenes*.

In addition to these observations it is a fact worthy of note that streptococci are frequently found associated with a considerable number of morbid conditions which thus far have not been satisfactorily attributed to any specific germ.

In human pathology the presence of streptococci is not unusual. The etiological value of *Streptococcus pyogenes* Ogston, and *Streptococcus erysipelatos* Fehleisen, is very generally conceded. Such affections as erysipelas, pyæmia, empyema, septicæmia, diphtheria, progressive gangrene, scarlatina, Impetigo contagiosa, pericarditis, osteomyelitis, and influenza have been attributed with more or less positive evidence to the invasion of certain streptococci. The investigations of the etiology of la grippe has revealed the fact that streptococci are very frequently associated with the inflammatory condition of the air passages in that disease. Prudden has made the observation that streptococci are found associated, apparently as the etiological factor, with those inflammations, particularly of the serous membranes, in which the formation of fibrin is a most marked feature.

Investigators are not unanimous in the belief that streptococci which have been found to be associated with the diseases mentioned belong to different species. It is a well known fact that their common morphological and biological properties are much more numerous than their differences, and that it is exceedingly difficult to point out a distinguishing trait of any one of these streptococci that is sufficiently characteristic to differentiate it from the others.

The description by Flügge of *Streptococcus pyogenes* applies equally as well to *Streptococcus erysipelatos*, and also to a large number of other streptococci which have no pathogenic properties by which they can be differentiated. Hajek could not find any morphological or cultural difference between *Streptococcus erysipelatos* and *Streptococcus pyogenes*,

but by inoculation experiments he found that they possessed marked differences.

Prudden compared very carefully *Streptococcus pyogenes*, *Streptococcus erysipelatos*, and *Streptococcus diphtheriæ*, but found that there was not a single constant feature of difference between them that could be detected by cultural characters (parallel cultures), or by inoculations into the smaller experimental animals.

Fraenkel isolated from a case of purulent peritonitis a streptococcus which had apparently played the part of a pyogenic agent, and succeeded in producing erysipelas on the ear of a rabbit with a pure culture of this streptococcus. When it was inoculated beneath the skin on the back of mice and rabbits it produced suppuration.

Prof. Welch was unable to determine any decisive differences between *Streptococcus erysipelatos* and *Streptococcus pyogenes*. He adds that "the efforts to differentiate into distinct species the pathogenic streptococci have thus far met with little success, so that the weight of opinion favors the view that the streptococci of erysipelas, phlegmonous inflammations, septicæmia, puerperal fever, and of the various forms of angina belong to one and the same species."

Klein, however, in his report on "The Morphology and Biology of the Streptococcus," in which he discusses the properties of nine selected streptococci, concludes that they are separate and belong to distinct species or varieties. He also believes that a large number of streptococci that have the appearance, on a superficial examination, of belonging to the same species, may, by careful study, be differentiated into separate species or varieties.

Von Lingelsheim has recently divided the streptococci into two groups; one non-pathogenic, called *Streptococcus brevis*, and the other pathogenic, called *Streptococcus longus*. The streptococci which he studied were from various sources, principally, however, from the normal human saliva and diphtheritic membranes. He made some interesting investigations upon the effect of disinfectants on the various streptococci which he studied. He lays much stress upon the importance of blood serum from various animals as a culture medium for these germs. His streptococci grew very vigorously on the serum from rabbit's blood, while they failed, with one exception, to grow on that from pig's blood.

Kurth, in his extensive work upon the differentiation of streptococci and their appearance, especially *Streptococcus conglomeratus* in scarlatina, makes the following provisional classification. *Streptococci rigidi*, which grow in short chains in bouillon, the sediment loose, the chains not hanging together. *Streptococci flexuosi*, which grow in long chains in bouillon, the sediment hanging together.

Pasquale, in an exhaustive discussion of the greater number of the streptococci that have heretofore been described, has tabulated the various properties of 33 different species, making note of their effects on milk, acid formations, pigment-producing properties, growths upon

various kinds of blood serum, and their pathogenic effects. Their morphology and cultural characters on the ordinary media are also carefully considered. The large variety of species with which he has worked has enabled him to take a more comprehensive view of the entire group of streptococci than had heretofore been done. The result of his study of the pathogenic powers of the different species of streptococci differs in many respects from those obtained by other authors. He has, as a result of his observations, formulated a new classification of this group of bacteria based upon their morphological and pathogenic properties. He does not, however, draw sharp lines between the different streptococci, but on the contrary groups them within the natural boundaries which he finds to exist between them.

Pasquale's classification of the streptococci is as follows:

I. SHORT SAPROPHYTIC STREPTOCOCCI.

- (1) Develop in a low temperature (Feces and external surroundings).
- (2) Develop in a higher temperature (Mouth and bronchial mucosa).

II. LONG, NOT VIRULENT, STREPTOCOCCI.

- (1) Feces. (Example, *Streptococcus coli gracilis*.)
- (2) Mucous membrane of the mouth (*Streptococcus* of Kruse u. Pansini).

III. LONG PATHOGENIC STREPTOCOCCI.

- (1) Streptococci of erysipelas, suppuration, pneumonia, diphtheria, scarlatina, etc.
- (2) Sputum of pneumonia (*Streptococcus* of Kruse u. Pansini).

IV. SHORT, HIGHLY INFECTIOUS, STREPTOCOCCI.

- (1) From tuberculosis, etc. (*Diplococcus pyogenes*).
- (2) From pneumonia (*Diplococcus pneumonia*).

It is believed that the investigations cited are sufficient to show the general scope of the work that has been done and the more important opinions entertained concerning this very interesting class of the shizomycetes, although a very long list of minor observations could be added. Without entering into detail, it may be stated that subsequent investigations have shown that in some cases, especially in human pathology, the streptococcus which was first supposed to be the etiological factor in the disease gave way to other bacteria* and in a few other cases the question is still an open one. With this brief review I will pass to the consideration of the streptococci that have come under my observation. It should be stated at the outset that the streptococci which are here considered were obtained exclusively from the organs and secretions of domesticated animals, and that no attempt is made to identify them with the streptococci that have heretofore been described. This is omitted on account of the great similarity,

**Streptococcus diphtheria* is a marked example of this fact. Prudden found this streptococcus almost invariably in the false membrane and occasionally in the spleen, liver, and kidneys in a series of twenty-four cases in children who perished with the disease. In none of these did he find the Klebs-Loeffler bacillus. In a later series of investigations, however, he found the Klebs-Loeffler bacillus in every case.

generally speaking, that exists in the morphological and biological characters between the streptococci isolated from different sources and the variability of their cultural characters when grown under different conditions.

The first streptococcus to which my attention was given was discovered by Dr. Theobald Smith, in the spring of 1887, while he was investigating an outbreak of swine plague.* Since that time several other outbreaks of swine disease have been investigated, in each of which one or more streptococci have been isolated from the diseased organs of one or more of the pigs that were examined. In addition to these, streptococci have been isolated from diseased organs taken from animals that died from varied and widely separated diseases. They have also been found to be quite numerous in the secretions covering the different mucous membranes of the animal body as well as in various extraneous material. This varied, and we may almost say, universal distribution of these organisms, renders it of much importance in view of the great similarity that is known to exist between them, that differential biological or morphological characters should be determined, if they exist, between the purely saprophytic streptococci and those that have a greater or less etiological value.

In all we have isolated during the past four years more than fifty streptococci, many of which perished before they were sufficiently studied to be considered here. In a few of the earlier cases streptococci, which appeared upon a somewhat superficial examination to be identical, were found in several organs of the same animal, and consequently only one culture was retained for further study and comparison. This was unfortunate, as subsequently it was found in a few cases that the streptococci that were present in different parts of the body could be differentiated by one or more distinct characteristics. A few of the streptococci were obtained in pure culture from the diseased organs of the animals that were examined, while others were isolated from impure original cultures by means of agar plates. The germs thus obtained have been carefully studied and compared microscopically and in their growth upon certain culture media. Various experimental animals have been inoculated with pure cultures of these germs, and subsequently very carefully watched in order to detect any effect that might have been produced by the inoculation. The greater number of the streptococci considered here were isolated from morbid tissues, but for the purpose of comparison a few that were obtained from the mucous membranes of certain animals are inserted.

The cultivation of these streptococci has shown them to be very sensitive to any change in the conditions under which they were grown, especially to any variation in the composition or chemical reaction of the culture media. On account of this extreme delicacy in the great majority of their differential biological characters, it seems best at

*his streptococcus was described by Dr. Smith in the Bureau Report for 1887.

this time to limit the descriptions of these characters to those more hardy properties which repeated cultures have shown to be constant, and consequently recognizable under slightly varying conditions as having a more or less differential value. It will be observed subsequently that the greater number of constant differences that exist between these streptococci were manifested in their physiological effect, and it is believed by the writer that when our methods for the determination of these properties are sufficiently elaborated the facts necessary for a specific differentiation of the various classes of the schizomycetes will be forthcoming.

Although several classifications of the streptococci have been made, there appears to be no system of subdivision which is applicable to all of the series of streptococci which have been described. My observations have shown that there are streptococci which possess biological characters that give them an intermediate position between the forms which have been designated as belonging to subgroups. On this account I have not adopted any of the classifications which have been formulated. The streptococci which I have studied, as the subsequent descriptions will show, exhibit a more or less marked variation in their various properties, but, with one exception, they were as sensitive to changing conditions of growth as *Streptococcus erysipelatos* and other recognized pathogenic forms. It would seem, therefore, that many of these forms have become parasitic in their habits. A classification based on the various morphological, biological, or pathogenic properties of a limited number of streptococci must continue to suffer modifications as more extended observations are made, until the saprophytic, parasitic, and pathogenic forms are more clearly defined, and the range of their biological variations more accurately determined.

Before considering the special qualities of the streptococci about to be described, a few of the more important properties which have been found to be common to them all may be mentioned:

1. They are readily stained with the ordinary aniline dyes.
2. They grow in gelatine, but do not liquefy it.
3. The growth on the different media is not viscid.
4. The growth at the ordinary temperature is less vigorous than at the temperature of the body (excepting streptococcus O).
5. In simple beef broth the growth is more feeble than in peptonized bouillon.
6. The growth is most vigorous in peptonized bouillon containing glucose.
7. With one exception (streptococcus O) the time during which cultures will remain alive, is very variable and uncertain. (It is due to this fact that several forms were lost before their characteristics were determined.)

In order to present, in a form most convenient for comparison, a description of the more important properties of the streptococci studied the following table has been constructed:

Streptococci.	Source and date.	Accompanying disease.	Length of chains.	Diameter of cocci.	Growth on solid media.		
					Agar.	Gelatine.	Potato.
A	Lung, pig, 1887...	Swine plague	Very long	0.8 μ oval	.....	Feeble...	No growth.
B	Spleen, pig, 1888 ..	Disease (f) ...	Long	0.6-0.9 μ ..	Nuclear...	do	Grayish ...
C	Lung, pig, 1889....	Hog cholera ..	Short and long.	0.7-0.9 μ ..	do	do .....	.....
D	do	do	do	0.7-0.9 μ ..	do	do .....	.....
E	Spleen, pig, 1889 ..	do	Long and very long.	0.5-0.7 μ ..	do	do	No growth.
F	do	Modified hog cholera.	do	0.7-0.8 μ ..	do †	do	Thin, grayish.
G	do	Disease (f) ...	Very long.	0.8-1.0 μ ..	do	do	Feeble
H	Lung, pig, 1889....	do	Short	0.7-0.9 μ ..	do	do .....	.....
I	do	Swine plague.	Long	0.6-0.7 μ ..	do	do	No growth.
J	Blood, pig, 1889....	Modified hog cholera.	do	0.6-0.7 μ ..	do	do	Feeble
K	Peritoneal exudate, pig, 1890.	Swine plague.	do	0.6-0.8 μ ..	do ‡	do .....	.....
L	Liver, pig, 1890....	do	do	0.8-1.8 μ ..	do	do .....	.....
M	Spleen, pig, 1890 ..	Disease (f) ...	do	1.0-1.5 μ ..	do †	do	No growth.
N	Kidney, cow, 1890 ..	Texas fever...	Short	0.8-1.0 μ ..	do	do .....	.....
O	Feces, cow, 1890 ..	Healthy	do	0.8-1.8 μ ..	Vigorous ..	Vigorous ..	.....
P	Trachea, pig, 1890 ..	do	do	0.8-1.0 μ ..	Nuclear ..	Moderate ..	.....
Q	Lung, cow, 1891	Pneumonia ...	Long	1.2-2.0 μ ..	Moderate ..	Feeble .....	.....
R	Abscess, knee, pig, 1891.	Chronic hog cholera.	Short	0.7-0.8 μ ..	do	do .....	.....
S	Abscess, elbow, pig, 1891.	do	do	0.7-0.8 μ ..	do	do .....	.....
T	Lung, cow, 1891	Pleuro-pneumonia.	do	1.0-2.0 μ ..	do	do	No growth.
U	Trachea, horse, 1891.	Healthy (f) ...	do	0.9-1.0 μ ..	Translucent.	do	Feeble
V	Lung, pig, 1891....	Swine plague.	Long	0.7-0.8 μ ..	Moderate ..	do	No growth.
W	Liver, pig, 1892....	Disease (f) ...	do	0.8-0.9 μ ..	Nuclear...	do	do
X	Blood, pig, 1892....	do	Short	0.7-0.9 μ ..	do	do	do
Y	Spleen, pig, 1892 ..	do	Long	0.7-0.8 μ ..	do	do	do
Z	Liver, pig, 1892....	do	Short	0.8-1.3 μ ..	Moderate ..	do	do
a	Blood, pig, 1892....	do	Long	0.7-0.9 μ ..	do	do	do
β	Nasal mucus, horse, 1892.	Glanders	Short	0.9-1.0 μ ..	Nuclear ..	do	do

*The streptococci from Q to β inclusive were cultivated in peptonized bouillon containing 2 per cent glucose in the fomentation tube. Streptococci Q, R, and S, did not develop in the closed portion of the tube. The growth in the open bulb was exceedingly vigorous. The others developed in both sides of the tube. The growth was more vigorous but otherwise similar to that in simple bouillon. The alkaline reaction of the bouillon was changed in every case to an acid one during their multiplication.

†There was no formation of pigment in the growth on the surface of agar.

‡An unusually vigorous growth.

§An unusually feeble growth.

||Several weeks.

twenty-eighth streptococci.

Growth in bouillon.*	Reaction.	Bouillon cleared.	Effect on milk.	Stain after—		Pathogenesis.
				Gram's method.	Weigert-Gram method.	
		<i>Days.</i>				
Flakes			Not changed..	Nicely		Destroys mice.
Faintly cloud'd, flakes.		10	Thickened in 30 days.	Not stained.	Not stained.	Local swelling in rabbits.
Uniformly clouded.		26	No change....	Nicely	Feebly	No effect.
do		19	do	do	do	Do.
Flakes, faintly clouded.		12	Casein coagulated.	Feebly	do	Destroys mice and rabbits.
Uniformly clouded.		25	No change....	Nicely	Nicely	No effect.
Flakes in suspension.		12	do	Feebly	do	Do.
Uniformly clouded.		10	do	do	do	Do.
do		3	Casein coagulated.	Nicely	do	Do.
do		40	Thickened....	do	Feebly	Do.
Flaky sediment.			No change....	Not stained.	Very feebly.	In rabbit elevation of temperature. Local swelling.
do			Casein coagulated.	do	Feebly	No effect.
Heavily cloud'd, flakes in suspension.		6	No change....	Nicely	Nicely	Do.
Turbid.		(||)	do	do	Feebly	Do.
do		15	Casein coagulated.	Not stained.	Not stained.	Do.
Faintly cloud'd.		8	do	Feebly	Nicely	Do.
Flocculent sediment.	Acid*		No change....	do	Feebly	Slight local reaction in rabbits.
Flakes	do		Casein coagulated.	do	Nicely	No effect.
do	do		No change....	Nicely	Not stained.	Do.
Uniformly clouded.	Alkaline..	8	Casein coagulated.	do	Nicely	Destroys mice and rabbits.
do	Acid.....	4	do	Feebly	Not stained.	Do.
do	Alkaline..	7	do	Nicely	Nicely	No effect.
Faintly clouded, flakes.	Acid.....	5	do	Feebly	Not stained.	Do.
do	do	2	do	Nicely	Nicely	Do.
do	do	4	No change....	do	do	Do.
do	do	2	do	do	Not stained.	Destroys mice.
do	do	2	do	do	Nicely	Destroys mice, rabbits, and pigs.
Very faintly clouded.	Alkaline..	6-8	do	do	do	No effect.

* According to observations recently made by Dr. Theobald Smith, the initial acidity of the cultures of many bacteria is demonstrably due to the presence of muscle-glucose in the bouillon. As this varies in quantity and is occasionally absent, the inconstant and conflicting results on the acid and alkaline reaction of cultures is readily explained.

A few explanations seem necessary, however, for an understanding of the terms employed in tabulating these facts:

1. In discussing these streptococci it was necessary to assign to each some name by which it could be designated. For this purpose the letters of the alphabet were chosen.

2. In the beginning of our work several of the tests were not employed that have been used in studying the forms more recently isolated.

3. The streptococci are given in the order of their discovery.

4. The words short, long, etc., used in designating the length of the chains, have been assigned the following arbitrary definite meaning: Very short chains are composed of from 3 to 4 cocci or segments; short chains of from 4 to 10 cocci; long chains of from 10 to 40 cocci; very long chains of more than 40 cocci. In the table these terms have reference to the growth in bouillon only. In cultures containing chains ranging from 3 to 50 or more cocci, the term has been employed that applies to the greatest number of individuals.

5. The media used were faintly alkaline in reaction. The agar, gelatine, and bouillon contained one-quarter per cent peptone and one-half per cent sodium chloride. Bouillon used in the fermentation tubes contained, in addition, 2 per cent glucose. The word "nuclear" is used to designate colonies from 1 to 2 millimeters in diameter (on the inclined surface of agar) which have a convex, grayish, opaque center, with a spreading translucent border. The word "moderate" represents a corresponding homogenous non-nuclear growth. In the growth in gelatine "feeble" indicates the development of colonies varying from one-eighth to three-fourths millimetre in diameter.

The fermentation tube* enables us to determine approximately the aërobic and anaërobic properties of the bacteria; as the liquid in the closed bulb is deprived of its air during the sterilization, all bacteria that grow in it can be considered as more or less anaërobic. The glucose was added in order to detect the power of the various streptococci to cause the fermentation of sugar with or without the production of gas.

BIOLOGY.

In addition to the media mentioned, glycerine agar, blood serum, agar-gelatine, glycerinated bouillon, acid bouillon, and potato broth have been employed in the cultivation of these streptococci. Although von Lingelsheim found blood serum very advantageous, my experience with the streptococci in question showed this medium to be quite unsatisfactory. (I have used the serum from cattle only.) The growth was variable on the various other solid media and in the bouillon con-

*Dr. Theobald Smith called attention to the value of the fermentation tube in bacteriological work in 1890. *Centralblatt f. Bacteriologie*, Bd. VII, p. 502. It is figured and briefly described by the same author in his Report on the Cause and Prevention of Swine Plague. U. S. Department of Agriculture, 1891, p. 81.

taining glycerine. Like the swine-plague germ, the great majority of these streptococci would not grow in acid bouillon, although many of them would change the reaction of the alkaline medium to an acid one during their multiplication.

The character of the growth in bouillon is interesting. With few exceptions it will be observed that the long-chained streptococci grew in flakes, while those composed of short chains imparted a uniform cloudiness to the liquid. This property was constant. *Streptococcus Q* was carried through a series of 20 subcultures made at short intervals with no alteration in the character of the growth. Shorter series were made with several of the other streptococci with the same result. In a few cases, there was a faintly clouded appearance of the liquid in which the streptococci grew very largely in flaky masses. The flakes are due to the interlacing of the chains, presumably during the process of multiplication. The time required for the liquid to become clear was very constant (as tested by several cultures), although it varied very much with the different species (?). The settling of the streptococci did not indicate their death, but the limit of their growth in the liquid. The sediment was not viscid.

Although the growth on agar and gelatine varied slightly, the constant characters were very similar, and, with few exceptions, these cultures could not be considered of any differential value. Their growth on potato, their aerobic and anaerobic powers, and their effect on the reaction of bouillon and the casein of milk show more marked differences. Although with every germ tested the reaction of the alkaline bouillon containing glucose was changed to a very acid one, no gas was produced. These facts are significant in showing the differential importance of the physiological properties of these bacteria.

In considering the minor differences that exist between these streptococci, especially those that were isolated from animal tissues, it should be remembered that they were obtained presumably at different periods of time after their invasion, and that there is no positive information by which we can determine the changes produced in their various properties by the influence of their new environments and the variable time in which they were subjected to them.

MORPHOLOGY.

When examined in a fresh condition, (hanging drop) with a magnification of 500 diameters, the chains appear, as a rule, to be made up of micrococci 0.7 to 1.8 μ in diameter. When stained with methylene blue, or fuchsin, they appear as deeply stained oval or spherical bodies. With a magnification of 1,000 diameters, the cocci, in the majority of the forms, appear to be more or less elongated. Many of these exhibit the polar stain or belted appearance quite characteristic of the swine plague group of bacteria, while others show simply a light unstained center. The spherical forms usually appear as deeply stained bodies.

In many species (?) there seems to be a tendency of the segments to be closely united in pairs. This is believed to be due to the incomplete division of the cocci. The Gram and Weigert-Gram staining methods can not be considered of much importance as means of differentiation, on account of the variable degree to which the stain is retained by the different species. The individual deviations from the typical streptococcus (micrococci united in chains) are as follows:

In streptococci A, F, G, O, Q, and W, the individual segments were oval, elongated, and resembled somewhat, in a stained specimen, the appearance of the swine plague organism. In G, the long diameter appeared to be transverse to the long axis of the chain. An examination of a properly stained specimen, magnified 1,000 diameters, revealed the fact that a single segment was composed of two of the supposed cocci separated by an unstained band. The ends were nearly square, giving them the appearance of minute rectangular parallelograms. In streptococci B, E, M, and U, the terminal cocci, and frequently one or two within the chains, were much larger than the other segments. When only two were present they were invariably at the extremities. They were never observed in the other streptococci, and their significance is still somewhat speculative. Streptococcus L presented a great variation in the size of the cocci and length of the chains. So varied was the size that it was thought for a considerable time that it was an impure culture. Repeated plate cultures, however, developed only one form of colonies which were composed of streptococci of a similar character. The shorter chains were composed of the larger cocci and the longer ones of the smaller cocci. This variation* was also present, but to a less degree, in streptococcus Z.

Streptococcus O varied very considerably when grown in different media. In bouillon the segments were spherical, while on agar and gelatine they were oval. The morphological as well as biological characters of this streptococcus indicated its close relationship to the ordinary saprophytic micrococci. The length of the chains in nearly all of the species varied with the media; usually they were longer in bouillon than on solid media, and longest in bouillon containing glucose.

Although considerable variation was found in the length of the chains, and in a few cases in the size of the individual cocci, there was no appreciable change produced by artificial cultivation in the morphology of any of these forms. Streptococcus Q was carried through a long series of cultures in a liquid containing very little nutriment (0.5 cc. of bouillon and 9.5 cc. of sterile distilled water). The number of chains was greatly diminished, but no appreciable change was produced in the morphology of the individual chains or cocci. Cultures in bouillon containing 1 per cent peptone gave similar results. It is

* Koplik and Van Arsdale have recently noted the variation in the diameter of the cocci, in the different chains of the streptococcus found by them in diseased joints (osteomyelitis).

interesting to note in this connection that in the pathogenic forms the chains were very short, and often single cocci appeared in cover-glass preparations from the organs of the dead animals. The few forms that were fatal to experimental animals possessed no morphological or biological peculiarities that would suggest their pathogenic properties, or separate them as a class or group from the others. The parasitic tendency in the cultural characters of all the streptococci (excepting O) was very marked.

It is observable that, while there are many minor differences, there is still a strong similarity existing between the different streptococci mentioned (excluding streptococcus O), and that the difference in the species of the host animal or the disease with which they were associated was not marked by any distinct characteristic of the invading streptococci. It will be observed from the table that in the differential tests no two of the streptococci that were studied gave precisely the same reaction throughout, but each streptococcus differed in some respect from all of the others. This fact appears to support Klein's statement that there is a specific or at least variatal difference existing between the streptococci (isolated from different sources) which appear in a superficial examination to be identical. In many cases, however, the variation was so slight that it seems possible to find its cause in external conditions rather than in the inherent properties of the germ.

The statements at hand concerning the variations in the morphology, biology, and pathogenic properties of certain bacteria as found in nature, and the power to modify to a greater or less degree these properties in certain species by cultivating them under different conditions, would warrant the supposition that many of the minor differences in these streptococci could have been brought about by the different influences to which they had been subjected prior to their isolation. The close resemblance of the streptococcus from the tracheal mucus of a pig (streptococcus P), to those found within the organs of diseased swine is at least suggestive in tracing the source of these organisms. The fact that intestinal and tracheal bacteria invade the inner organs and cavities of the body is so well established that it is not difficult to believe that streptococci, known to be more or less numerous in the flora of the mucous membranes of the healthy animal, should occasionally, under favorable conditions, make their way into the various organs of their host.

A few very interesting differences in the reaction of streptococci isolated from different organs of the same animal have been observed. Streptococci G and H were isolated from the liver and lung respectively of a pig that presented the lesions on post-mortem examination of a somewhat modified case of swine plague. In sections of the lung streptococcus H was seen winding in and out among the cells in the alveoli. As there was considerable lung disease but no swine plague

or hog cholera bacteria discovered, the pathogenesis of this germ was thoroughly tested on mice and rabbits, but with negative results. Streptococcus G grew without exception in the longest chains of any form studied, but like streptococcus H it produced no effect on animals, the difference between them existing in their morphology and biology.

Streptococci R and S were isolated from the pus in the joint abscesses (knee and elbow) of a pig that died of chronic hog cholera. (The hog-cholera bacilli were obtained from the same abscesses). As they were isolated from the abscesses, produced presumably by the same cause in the same animal, it is evident that they were subjected to practically the same conditions after their invasion. They were not distinguishable excepting in their reaction to Gram's and Weigert-Gram's staining processes and in their effect upon milk, where repeated experiments proved conclusively that streptococcus R would invariably coagulate the casein, while streptococcus S produced no appreciable change. The constancy in their reaction to the staining reagents was likewise determined. A third and similar illustration of this peculiar variation of streptococci inhabiting the same host and apparently identical in the majority of their characteristics is found in streptococci Z and α . These were obtained from the same animal and differed principally in their virulence, the one being fatal to mice only, the other destroying mice, rabbits and swine.

Pasquale makes the remark that streptococci differing in their characters were isolated from different organs of the same animal.

OTHER STREPTOCOCCI.

The streptococci that perished before they were studied sufficiently to be considered here did not, as far as they were observed, present any characteristics that were markedly different from those here described. A large number of them were inoculated into mice or rabbits, or both, but always with negative results. There are, however, several streptococci that have been isolated and studied more or less thoroughly, which have not been included in the preceding series, but which appear to be of sufficient importance in throwing light upon the distribution of the delicate and more saprophytic forms of streptococci to be briefly considered. A glance at the table will show that streptococcus O (isolated from the feces of a cow) differs very decidedly from the other forms in its biological characters, and that in every way it was more saprophytic in its tendencies. Several apparently similar streptococci have been isolated, which, upon subsequent cultivation, lost their power to grow in chains and appeared as ordinary saprophytic micrococci or diplococci. Some of these only softened gelatine, while others liquefied it. I will describe briefly two of these supposed streptococci:

(1) *April 4, 1890.*—I examined a rabbit which had a large and apparently closed abscess in one of its nasal cavities. From the pus in this abscess I obtained a strep-

tococcus. It grew in short chains, and was composed of micrococci 1.2 to 1.5 μ in diameter. It stained nicely after Gram's method, and grew very vigorously on the ordinary media. After about four generations, however, it ceased to grow in chains, and appeared subsequently as simply micrococci.

(2) From the tracheal mucus of a sheep a streptococcus was isolated by means of gelatine plates. It consisted of micrococci 1.2 to 1.8 μ in diameter, united in short chains. It took the Gram stain and grew very vigorously on all of the ordinary media. After a few generations very few chains were observed, but diplococci and single germs appeared in large numbers. It liquefied gelatine. The variations in the size of the cocci is especially worthy of note.

During an investigation of an outbreak of abortion in mares, cultures were made from the vaginal secretion of five healthy animals, from four of which a streptococcus which grew in long chains was obtained, which, in the minuteness of its structure and delicacy of its cultural characters, surpassed any of those described in this article. The streptococci from the different animals appeared to be identical in their microscopic appearance and growth on certain media. They were cultivated only with difficulty. In the examination of Potomac river water and a series of soil examinations various streptococci were found, some of which, upon superficial examination, presented characteristics of strongly saprophytic bacteria, while others were parasitic in their tendencies. Dr. Smith gave me a culture of a streptococcus isolated by him from drinking water that was biologically as parasitic in its tendencies as any of those obtained from the organs of diseased animals.

Although these observations on streptococci from extraneous material could be multiplied, the facts stated are sufficient to show the wide variations found to exist in this group of bacteria, and that those forms which we have isolated from the organs of diseased animals do not possess, biologically, parasitic tendencies that are not equally as well marked in some of the streptococci found apparently in their normal habitat in nature. These facts are of much importance in considering the economic value of this group of bacteria.

PATHOGENIC PROPERTIES.

It will be observed from the table that fifteen of the streptococci were obtained from the organs of animals that had perished from a known disease, while nine of them were isolated from animals that were either healthy or that had died from a disease the specific cause of which was not positively determined. These facts are important in their bearing upon the economic value of these forms. Of the twenty-eight streptococci described, six were fatal to some one or more of the experimental animals. The source of these destructive forms shows that two of them were associated with specific disease germs; two were found in a pig in which no disease germ was discovered, although the pig was from a herd in which several of the animals had succumbed to hog cholera: one from a pleuro-pneumonia lung, and the other was

from the tracheal mucus of a lame, but otherwise healthy horse. In addition to these, three of the forms produced more or less local reaction in rabbits, but apparently had no effect on mice. Of these, two were associated with specific pathogenic bacteria, and the third was found in the organs of an animal that perished from an undetermined disease. The other nineteen forms exhibited no pathogenic properties whatever. In addition to the usual subcutaneous and intravenous inoculations several of them were injected in large quantities into the pleural and abdominal cavities of rabbits with no appreciable effect. It should be observed that six of the nine more or less pathogenic forms grew in long chains, while in the other three the chains were short.

Besides the fact that 79 per cent of these streptococci, and all of a considerable number of other forms isolated from similar sources, failed to destroy experimental animals, we should note a few other general facts which are important in considering the pro and con of their etiological value.

1. The streptococci were isolated from a very large variety of lesions, from many of which the specific germ was obtained.

2. Comparatively speaking, a small minority of apparently similarly affected organs contained streptococci.

3. The streptococci isolated, even those from undoubtedly the same kind of lesions, were not identical as indicated by the various differential tests applied.

In these respects my observations have differed from those of Fehleisen, Klein, Schütz, and others who have attributed specific etiological value to certain of the streptococci which they have studied. It will be remembered that in their investigations the same streptococci were found to be nearly or quite universally present in a greater or less number of similarly diseased conditions.

As my observations and results do not conform with the necessary requirements to establish a specific pathogenesis for a micro-organism, it would seem that the streptococci here described (that were obtained from animal tissues) must be considered as having accidentally* invaded the organs from which they were isolated. Their etiological effect is therefore reduced to a secondary place, which assures them of no greater economic value than that possessed by a large number of other bacteria that are frequently found in diseased animal tissues. A more detailed account of the inoculation experiments with the nine pathogenic forms is appended:

Streptococcus A.—For the pathogenic effect of this streptococcus I quote from the Report of the Bureau of Animal Industry for 1887: "Two rabbits and two mice were inoculated subcutaneously with one-twelfth cc. each of a pure bouillon culture. Both

*By the term "accidentally" is meant a passive invasion, brought about by conditions produced by other causes in contradistinction to the invasion of virulent pathogenic bacteria.

mice were found dead on the morning of the second day. One, on account of decomposition, was not examined; the other presented at the point of inoculation a slight reddish serous infiltration containing numerous streptococci. There was a moderate number in the spleen and blood from the heart. The two rabbits remained well. Cultures of this microbe were injected beneath the skin into the thorax and trachea of pigs without causing any disturbance."

Two series of inoculations in mice were made with this streptococcus for the purpose of testing the effect of repeated inoculations upon the virulence of the germ. The first mouse was inoculated with a pure culture, the second from the blood of the first and so on. The appended table is self-explanatory:

Inoculation experiments.

Mouse No.	Date of inoculation.	Inoculated subcutaneously with—	Date of death.	Time required to destroy life.	Remarks.
1	1887. Aug. 15	2 to 3 drops bouillon culture.	1887. Aug. 17	2 days	Streptococci in blood and spleen not found in cover-glass preparations from liver.
2	Aug. 17	Loop blood mouse 1..	Aug. 20	3 days	Do.
3	Aug. 20	Loop blood mouse 2..	Aug. 25	5 days	Do.
4	Aug. 25	Loop blood mouse 3..	Aug. 29	4 days	Do.
5	Aug. 29	Loop blood mouse 4..	.....	.....	Remained alive and well.

A second series gave the same result, showing that the streptococcus lost its virulence very rapidly.

Streptococcus B.—This streptococcus was obtained in pure cultures (bouillon and agar) from the spleen of a pig that died at the Experiment Station apparently from a disease of the liver. Mice inoculated subcutaneously with a pure culture of this microbe remained apparently perfectly well. A rabbit inoculated in a similar manner with 0.25 cc. of a turbid suspension in bouillon of the growth from an agar culture exhibited on the following day considerable reddening and slight swelling at the point of inoculation. No elevation of temperature. These symptoms soon disappeared.

Streptococcus E.—This streptococcus was obtained from the spleen of a pig. The animal was one among others that perished in an outbreak of modified hog cholera near Washington, D. C., in 1889. Streptococci C and D were obtained from pigs in the same outbreak.

Mice inoculated subcutaneously with from 1 to 3 drops of a bouillon culture died in from 2 to 14 days. The livers and spleens hyperæmic. Coagulation necrosis in the liver when the animals lived several days after inoculation. Stained cover-glass preparations from the organs showed the cocci single, in small clumps, and short chains, never in long chains. Pure cultures of the streptococcus were obtained from the organs in every case. A rabbit inoculated with one-eighth cc. of a bouillon culture in the ear vein died within 24 hours. Slight enlargement of spleen, liver hyperæmic, blood-stained serum in pericardial sac. In stained cover-glass preparations of the blood a few micrococci, usually in pairs, were discovered. No bacteria were observed in similar preparations from the spleen. Pure cultures of the streptococcus were obtained from both spleen and blood. A rabbit inoculated subcutaneously with one-fourth cc. of a bouillon culture was found dead on the seventh day. Surrounding the point of inoculation a slight injection of the blood vessels. Over the coils of the intestines, liver, and spleen a thin, semi-membranous exudate. Spleen somewhat enlarged, liver hyperæmic. The exudate contained a large number of single micrococci, also short chains. No bacteria were observed in stained cover-

glass preparations from the spleen, liver, and blood. A pure culture was obtained from the spleen. This streptococcus lost its virulence after having been cultivated for about one year, so that it would not destroy either mice or rabbits even when inoculated with very large quantities of a pure culture.

Streptococcus K.—This germ was associated with swine plague bacteria in a bouillon culture which was made from the peritoneal exudate of a pig that died of swine plague in an outbreak of that disease in New Jersey in 1890. (*Streptococcus L* was obtained from the liver of another pig in the same outbreak.) It produced no effect on mice. A rabbit was inoculated subcutaneously with 0.25 cc. of a turbid suspension of agar growth in bouillon. On the following day there was considerable reddening and slight swelling at the point of inoculation, temperature 104.4° F. (Normal temperature 103° F.) On the second day the rabbit appeared unwell; the fur was ruffled and it ate sparingly. Temperature 103.6° F. The next day it appeared well. Temperature normal and the local reaction had subsided.

Streptococcus Q.—This germ was found in large numbers in the lung of a cow affected with pneumonia (bronchial?). It produced no appreciable effect on mice. A rabbit inoculated in the ear vein with 0.25 cc. of a bouillon culture appeared unwell on the following day. Temperature 102.8° F. A rabbit inoculated subcutaneously in the ear with a loop of the surface growth from an agar culture developed a small abscess at the point of inoculation, with slight reddening of the surrounding tissue. No other symptoms.

Streptococcus T.—This was obtained from a plenro-pneumonia lung in 1891. Mice inoculated subcutaneously with a few drops of a bouillon culture died in from 3 to 4 days. No local reaction. Abdominal organs more or less hyperæmic. In cover-glass preparations from the spleen and liver were a large number of oval bacteria, surrounded apparently by a capsule. Pure cultures of the streptococcus were obtained from the blood. A rabbit inoculated in the ear vein with 0.50 cc. of a bouillon culture was found dead on the fifth day. The heart, muscles, and abdominal organs pale. About the right knee joint were several small abscesses in the inter-muscular tissue containing grayish pus. No other abscesses were found. No bacteria were observed in stained cover-glass preparations from the blood, liver, and spleen. In a similar preparation from the abscesses about the joint a large number of micrococci single, in pairs, and in short chains, were found. A pure culture was obtained from the blood.

Streptococcus U.—On June 24, 1891, two rabbits were inoculated with the mucus from the trachea of a horse which was killed on account of lameness. One of the rabbits died on June 28, from the organs of which this streptococcus was obtained. No other bacteria were discovered. Mice inoculated subcutaneously with a pure culture died on the fifth day. At the place of inoculation there was a purulent thickening of the skin and subcutis over an area one-half inch in diameter. Liver, spleen, and kidney swollen and discolored. No bacteria found in stained preparations made from the local lesions. Pure cultures were obtained from the spleen and blood.

A rabbit, which was injected subcutaneously with 0.10 cc. of a bouillon culture died on the second day. At the point of inoculation there was a slight injection of blood vessels. Liver pale, spleen enlarged, dark, and friable. Kidneys hyperæmic. Punctiform hemorrhages in lower colon. Lung emphysematous. Blood-stained serum in pericardial sac. Many cocci, usually in short chains, in cover-glass preparations from the organs. A pure culture from the blood. After four months this germ had lost its virulence to such a degree that a rabbit inoculated subcutaneously with 0.2 cc. of a bouillon culture remained well. It was reinoculated with 0.5 cc. five days later, and died on the second day following the inoculation. At point of inoculation a slight purulent infiltration into the subcutis, liver reddened, swollen, and sprinkled with minute round grayish areas (coagulation necrosis?). Spleen much enlarged, dark-colored, and friable. Considerable blood-stained liquid in

pericardial sac. Cover-glass preparations showed many micrococci, but no chains or capsules were observed. After five months (nine months in all) 0.75 cc. of a bouillon culture destroyed a rabbit in five days. A slight local reaction; exudative peritonitis; exudate contained cocci. Spleen dark. Liver enlarged, hyperemic, kidneys reddened. Many bacteria appeared in preparations made from the liver, but few in those made from the blood. Pure cultures were obtained from the organs.

Streptococcus Z.—This germ was found in the liver of a pig that died in an outbreak of swine disease in Illinois in 1892. No hog-cholera or swine-plague bacteria were found in this animal, although the hog-cholera germ was found in several of the animals that perished in the same outbreak. Two mice inoculated subcutaneously with this streptococcus died, one on the fourth and the other on the fifth day. At point of inoculation a purulent thickening of the skin and subcutis extended over an area one-half inch in diameter. Livers pale (fatty), spleens and kidneys congested. Stained cover-glass preparations from the internal organs showed no bacteria, while those from local lesions exhibited a very large number of micrococci. Agar tubes inoculated with the blood of the first mouse that died, and with the spleen of the second one, developed pure cultures of the streptococcus. A rabbit inoculated subcutaneously with 0.75 cc. of a bouillon culture remained perfectly well.

Streptococcus α.—This organism was obtained from the blood of the same pig from which streptococcus Z was isolated. Mice inoculated with this germ died on the third day, and presented lesions similar to those produced by streptococcus Z. The local lesion was more extended in this case.

A rabbit that received 0.25 cc. of a bouillon culture in the ear vein was found dead on the following morning. Blood-stained liquid was found in the peritoneal cavity and pericardial sac. Heart muscle (right ventricle) hemorrhagic. Enormous numbers of oval bacteria, many of which exhibited a light central band, were found in cover-glass preparations from the various organs. They were usually united in short chains. A rabbit inoculated subcutaneously with 0.75 cc. of a bouillon culture remained well.

March 1, 1892, two pigs (Nos. 91 and 92) were each inoculated intravenously with 5 cc. of a bouillon culture. On the following day both animals were apparently unwell, ate sparingly, and moved about very little. March 4, improvement in appetite and general appearance, but both animals used the right fore leg very little. March 6, appetite fairly good, but pigs have no use of their right forelimbs. March 7, no apparent change in their condition when seen in the morning. At 1 p. m. pig 91 was found dead; examination made at once.

Pig No. 91 (female), Essex grade, aged 3 months, weight 65 pounds, condition good. The capsular ligament of the right shoulder joint thickened, deeply reddened areas on the inner surface, otherwise the capsule pale and apparently necrosed. Articular cartilage normal in appearance. An infiltration of a thick yellowish purulent substance in the intermuscular tissue surrounding the joint. Other joints normal.

In the abdominal cavity about 300 cc. of light amber-colored liquid, which coagulated on exposure to the atmosphere. A few elastic shreds adhered to the abdominal parietes. Spleen very much enlarged, discolored, and on the lesser surface several blood tumors. Liver swollen, hyperemic. Kidneys swollen, surface mottled. A microscopical examination showed parenchymatous degeneration of both liver and kidneys. Stomach contained a small quantity of undigested food; mucosa of fundus slightly congested and pigmented. Upper portion of the duodenal mucosa sprinkled with stellate areas of blood injection; mucosa and contents deeply bile-stained. This was true of the small intestine throughout. Large intestine normal. Lungs hyperemic and slightly emphysematous; a considerable area of the right lung agglutinated to costal surface by a fibro-gelatinous substance. An area 4 by 2 cm., of right lung, was deeply congested and partially hepatized. Heart well

filled with post-mortem clots; several punctiform hemorrhages on right auricle and base of right ventricle.

Stained cover-glass preparations from the various organs showed many micrococci, often in short chains. In the liver, the chains were from 4 to 8 cocci long, surrounded by an unstained border which appeared to be a capsule. From the peritoneal and pleural exudates, and from the organs pure cultures of the streptococcus were obtained.

Pig No. 95 remained apparently quite well, excepting the loss of the use of the right fore limb. Killed for examination March 23. Female, Essex, weight 90 pounds, in good condition. Right elbow joint considerably enlarged, articular surfaces normal, capsule very much thickened, cartilaginous and sprinkled with centers of ossification. Spleen considerably enlarged, engorged and on section shows a few hemorrhagic infarcts. Otherwise the tissues appeared to be normal. No bacteria found in cover-glass preparations made from the different organs, and media inoculated from the organs remained sterile.

The appended table contains a summary of the inoculation experiments with the pathogenic forms:

Summary of inoculation experiments with the pathogenic streptococci.

Streptococcus.	Fatal to—	Time required in destroying life.	Remarks.
A.....	Mice	2 days	Serous infiltration at point of inoculation; streptococci in spleen and blood.
B.....	Mice.....	2 to 14 days...	Slight local reaction in rabbits. Spleen and liver hyperæmic; coagulation necrosis in liver when life was prolonged for several days.
E.....	Rabbits (ear vein) ...	24 hours	Spleen slightly enlarged.
	Rabbits (subcutaneously).	7 days	Local reaction; exudative peritonitis; many streptococci in exudate.
K.....			Local reactions and elevation of temperature in rabbits.
Q.....			Slight effect on rabbits; local abscess; no fever.
T.....	Mice	3 to 4 days...	Spleen and liver hyperæmic.
	Rabbits (ear vein) ...	5 days	Small abscesses in intermuscular tissue.
U.....	Rabbits (subcutaneously).	2 days	Spleen and liver hyperæmic; punctiform hemorrhages in colon.
Z.....	Mice	2 to 4 days...	Local reaction; spleen and liver hyperæmic.
	Mice	3 days	Local reaction; spleen and liver hyperæmic.
	Rabbit (ear vein) ...	24 hours	Spleen and liver hyperæmic; innumerable streptococci in organs.
α	Pig* (in vein).....	7 days	Inflammation about right shoulder joint; spleen, liver, and kidneys hyperæmic; streptococci in organs.

*Streptococci A α and are the only ones that were inoculated into pigs.

Unfortunately streptococci Z and α perished before a further study could be made of their pathogenic properties.

Although the effect produced on animals by the nine pathogenic streptococci varied to a greater or less degree, in general the lesions produced were more characteristic of septicæmia and pyæmia than of any other general or local disease. The localization of the lesions in rabbits appeared only when the animals lived for several days—a condition comparable to that produced by attenuated rabbit-septicæmia bacteria. The comparatively rapid attenuation of the more virulent streptococci (excepting α , which perished before this point was determined) is also observable. This is important, as it points to a temporary virulence rather than to distinctive specific pathogenic species. The temporary virulence may, in some cases at least, be explained on the

ground suggested by Lesage and Macargne,* who discovered that *Bacillus coli communis* acquired more or less virulence when exposed in diseased animal tissues.† Although we are not able to show that streptococci were in any case primarily the cause of the lesions in which they were found, or that they are capable of producing any disease in the experimental animals manifested by characteristic lesions,‡ their multiplication within the organs of the body undoubtedly had a more or less secondary influence in the production of the lesions from which they were obtained. The similarity that exists between the description of the streptococcus, supposed to be the cause of strangles and streptococcus U of this series, should be noted. The toxic effect of filtered or sterilized cultures of these streptococci was not tested.

The organs from which these streptococci were originally obtained presented such a variety of appearances that it was impossible to predict with any degree of certainty the presence of streptococci in any of the lesions examined. This is further evidence of their accidental invasion and non-specific etiological value. The results obtained and recorded in the preceding pages—limited and variable as they are—appear to be sufficiently clear to warrant the following conclusions:

CONCLUSIONS.

1. Streptococci are very generally distributed in nature, and especially on the mucous membranes of healthy animals. They fall very naturally into two classes: (1) Those that are strongly saprophytic in all of their properties; and (2) those that have decidedly parasitic tendencies in their morphological and cultural characters. The second class only has been found (by the writer) in diseased animal tissues.

2. Under certain conditions, presumably a weakened condition of the body with lesions of the mucosa in the air passages or intestinal tract, the streptococci of the mucous membranes invade the inner cavities and organs of the body. The large number of streptococci frequently found in the tissues indicate their invasion and subsequent multiplication prior to the death of the animal.

3. The streptococci that have been isolated in my investigations are capable of being differentiated by one or more distinct and apparently constant characteristics. In several instances, however, the differences are very slight, and may be due to previous conditions of life or unobserved irregularities in their cultivation.

4. Streptococci, quite as delicate and parasitic in their *cultural characters* as those obtained from diseased organs, are found in the flora of water and the mucosa of healthy animals, although no two of these

*Archiv. de Med., Exper. No. 2, 1892.

†A series of experiments is now in progress which it is hoped will throw some light upon this question with reference to certain streptococci.

‡Excepting more or less purulent infiltration of the subcutaneous tissue at the point of inoculation and general changes indicative of septicæmia or pyæmia.

contrasted species (?) have been found that possess precisely the same properties.

5. The grouping of the pathogenic and non-pathogenic streptococci by von Lingelsheim into *Streptococcus longus* and *Streptococcus brevis* does not hold true with all the forms that I have studied. The pathogenic effect of at least the majority of the destructive forms is septic in its character. Their virulence is soon lost.

6. Like other bacteria, streptococci are frequently found in the organs of animals that have perished from different and widely separated diseases. A few of these streptococci, as well as a small per cent of those from other sources, have been found to be fatal to certain of the experimental animals, while a large majority of them possess (when isolated) no pathogenic powers whatever as indicated by animal inoculations.

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A NON-MOTILE PATHOGENIC BACILLUS CLOSELY RESEMBLING THE BACILLUS OF HOG CHOLERA FOUND IN THE LUNG AND THE SPLEEN OF A PIG.

By VERANUS A. MOORE.

In the bacteriological examination of the spleen and a portion of the lung of a pig early in 1891, a non-motile bacillus was discovered which, on account of its pathogenic properties, has been somewhat carefully studied. Its appearance in a bouillon culture from the spleen and in stained cover-glass preparations from the bronchial secretions of the lung suggested a slightly modified form of the swine-plague germ. Further investigation, however, showed that biologically and in its effect upon animals it resembled very closely the hog-cholera bacillus. In the lung it was associated with attenuated swine-plague bacteria, but it appeared in a pure culture from the spleen. Unfortunately the other organs of this pig were not bacteriologically examined.

The pig from which this bacillus was isolated was of Essex grade, about 10 months old, and weighed 50 pounds. For several weeks prior to its death it had been kept in a pen at the Experiment Station with three other pigs. It had not been exposed to any swine disease. The other animals remained well. From the autopsy notes I take the following:

There was extensive broncho-pneumonia of the cephalic and median lobes, and small areas of hepatization in the principal lobes of both lungs. No pleurisy. Abdominal organs apparently normal. A comminuted fracture of the right femur and suppuration, the pus burrowing in all directions, but more especially downward. Both hock-joints much enlarged and deformed. The injury to the femur was probably due to fighting.

The spleen and a small portion of the right lung* were removed with antiseptic precautions, and taken to the laboratory in a sterilized bottle and jar. These tissues were examined at once. No bacteria were found in cover-glass preparations from the spleen. A tube of bouillon inoculated with the spleen pulp developed a pure culture of a

*The piece of lung received at the laboratory was quite firm, pale, the lobules separated by opaque grayish lines, due to thickening of the interlobular tissue. The surface mottled with grayish, more or less elevated nodules, varying from one-half to two millimeters in diameter. On section the nodules appeared as grayish necrosed tissue. Upon pressure, muco-pus exuded from the larger bronchioles. Near the border there was ecchymosis beneath the pleura.

non-motile bacillus. Cover-glass preparations from the muco-pus from the bronchioles contained a very large number of oval, elongated bacteria slightly larger than the swine-plague germ. A smaller number of apparently the same bacteria were found in similar preparations from the consolidated lobules. A rabbit inoculated subcutaneously with the hepatized tissue died of swine plague on the fourth day. The characteristic polar-stained bacteria were found in cover-glass preparations from the organs. Plate cultures in agar developed colonies of swine-plague bacteria only. A second rabbit, inoculated with the muco-pus from the bronchioles, died on the eleventh day with lesions resembling those produced by hog-cholera bacteria. Pure cultures were obtained from the spleen, liver, and blood of a non-motile bacillus slightly larger than that of swine plague, but apparently identical with those obtained from the spleen of the pig.

The marked difference in the character of the lesions and the number of bacteria present in the organs of the two rabbits led to further investigations of the bacteria obtained (1) from the hepatized lung tissue, (2) from the muco-pus of the bronchioles, and (3) from the spleen. The methods employed and the results obtained were as follows:

INOCULATION OF RABBITS.

The necessary information concerning the inoculations for differential purposes is summarized in the appended table:

Rabbit No.	Date of inoculation.	Tissue and cultures inoculated subcutaneously.	Date of death.	Time required to destroy rabbits.	Remarks.
1	1891. Jan. 9	Hepatized tissue pig's lung.	1891. Jan. 14	5 days	Severe local reaction, peritonitis, swine-plague bacteria. Do.
2	Jan. 24	0.01 cc. bouillon culture rabbit No. 1.	Jan. 28	4 days	
3	Jan. 9	Muco-pus bronchioles, pig's lung.	Jan. 20	11 days ...	Local reaction; no peritonitis; necrosis in liver; very few bacteria in organs.
4	Jan. 22	0.01 cc. bouillon culture rabbit No. 3.	Jan. 26	4 days	Slight local reaction; no peritonitis; few bacteria.
5	Jan. 17	0.01 cc. bouillon culture pig's spleen.	Jan. 20	3 days	Slight local reaction; necrosis in liver; few bacteria.

The examination of rabbits Nos. 1 and 2 showed typical lesions of attenuated swine plague. There was severe local reaction and peritonitis with the polar-stained bacteria in cover-glass preparations. The lesions in rabbits Nos. 3, 4, and 5 were characterized by local reaction, which was slight in Nos. 4 and 5; enlarged, discolored spleen; necrosis in the liver; heart muscle pale. In stained cover-glass preparations from the spleen and liver were very few elongated oval bacteria slightly larger than the swine-plague germ and usually united in pairs. They exhibited a *light unstained center and deeply stained periphery*. In similar preparations from the blood a much smaller number of bacteria was found.

The fact that the rabbit which was inoculated with the virus from the bronchioles lived a day longer than the one inoculated with the culture from the spleen, is worthy of note, as it points to the supposition that the bacteria after penetrating the spleen had become slightly increased in their virulence.

It should be observed that in the cover-glass preparations from the bronchial secretions and the hepatized lung tissue of the pig there was not the visible difference in the size of these bacteria that was apparent in the preparations made from the organs of rabbits that perished from their inoculation, or from subsequent cultures.*

CULTURE TEST.

Repeated cultures were made on all of the ordinary media of the bacteria obtained from the organs of the pig. Those made from the hepatized lung tissue and from the germ obtained from the rabbit inoculated with the same could not be distinguished from cultures of swine-plague bacteria. The cultures made from the bacteria obtained from the spleen and from the muco-pus of the bronchioles, by rabbit inoculation, could not be differentiated. They were identical in every respect, and resembled similar cultures of hog-cholera bacteria as the subsequent description will show.

DESCRIPTION OF THE BACILLUS.

Morphology.—A non-motile, rod-shaped germ, from 1.0 to 2.0 μ in length and from 0.7 to 1.2 μ in thickness. In stained cover-glass preparations from an agar culture they are about 1.0 μ long and from 0.7 to 0.8 μ wide; the ends are rounded, giving them the appearance of elongated ovals. In bouillon they are appreciably larger, usually single, but occasionally united in pairs. In stained preparations from the tissues of rabbits they are much larger (1.5 to 2.0 μ long and from 0.8 to 1.2 μ wide). The periphery stains more deeply than the central portion; this is also frequently observed in preparations from cultures. It does not retain its coloring matter when treated after the Gram or Weigert-Gram methods.

Biology.—Agar at 36° C. On the surface of agar, after 24 hours,

*The non-appearance of the swine-plague germ in the organs of the rabbit inoculated with the muco-pus of the bronchioles is explained by the fact that they were very largely localized in the hepatized tissue as shown from the plate cultures. In preparing the material for inoculation the surface of the lung was scorched and an incision made with a sterile knife. The section was then scorched and the muco-pus obtained by pressure. The few swine-plague bacteria that were presumably present in the secretions were, on account of their attenuation, overcome by the great excess of other bacteria. It is probable that the swine-plague germs in this case belonged to the tracheal bacteria not distinguishable from those of swine plague that are normally present in the air passages of many healthy swine. (See report on Swine Plague, U. S. Department of Agriculture, 1894, p. 107.)

round, convex, grayish, non-viscid colonies appear, varying from 0.5 to 1.5 mm. in diameter, according to the number present. The edge of the colonies is sharply defined, the surface glistening. Within the agar small grayish colonies develop. When grown on agar plates ("double dishes") a peculiar, somewhat musty, penetrating odor is given off.

Gelatine.—At the ordinary temperature the growth is quite slow. After several days round, convex, glistening colonies are developed. Within the gelatine the colonies are smaller, 0.7 mm. in diameter, which have, under a hand lens, a slightly yellowish color and homogeneous appearance. The gelatine is not liquefied.

Potato.—At 36° C. a thin, brownish growth is formed over the surface. The growth continues slowly for several days. In old cultures it is of a yellowish brown color.

Alkaline peptonized bouillon.—After twenty-four hours, at 36° C., the liquid is uniformly heavily clouded with a very slight quantity of a grayish sediment. No appreciable odor. Acid reaction, a few bubbles at surface. In two weeks the liquid is nearly cleared, with the formation of a grayish, friable sediment. At this time the reaction is alkaline.

Acid peptonized bouillon.—In this medium the growth is quite feeble, imparting a faintly uniform cloudiness to the liquid. A grayish band composed of bacteria is formed on the sides of the tube at the surface of the liquid. The reaction becomes alkaline in about two weeks.

Alkaline peptonized bouillon, plus 2 per cent glucose.—In fermentation tubes containing this liquid the growth is quite vigorous throughout. The liquid becomes clouded and acid after twenty-four hours. Gas is formed, which replaces about one-third of the liquid in the closed bulb. The fermentation is very slow; only a few bubbles of gas appear in the first twenty-four hours. The fermentation is completed in about six days. When treated with a solution of caustic potash about one-third of the gas is absorbed. When the remaining gas is brought in contact with a flame there is a feeble explosion.

Milk.—In this medium, at 36° C., the growth is vigorous. In stained cover-glass preparations, the bacteria are often observed in clumps. The milk remains unchanged in appearance for about two weeks, when it presents a pearly, semi-translucent appearance. A microscopical examination shows that the fat globules are destroyed.* It is strongly alkaline in reaction. The casein is precipitated by the addition of a few drops of acetic acid. There is a doubtful peptone reaction.† A few experiments were made to test its power of resisting drying, and to determine its thermal death point.

*This peculiar appearance of the milk is also produced by the hog-cholera bacteria, but usually a much longer time is required.

†As a few drops of caustic potash or soda solution added to a tube of milk will produce the same appearance, it is probable that the change is largely due to the alkali which is produced during the multiplication of the bacteria.

Drying.—Cover-glasses were placed on a glass stand and covered with a bell jar, all of which were previously sterilized. A drop of a bouillon culture, one day old, was placed, by means of a flamed pipette, on each cover-glass. A tube of bouillon was inoculated with one of these cover-glasses on each day for seven consecutive days. The tubes inoculated on the fifth, sixth, and seventh days remained sterile. The others developed pure cultures of the bacillus.

Thermal death point.—Five tubes of bouillon were inoculated with about six drops each of a fresh bouillon culture and heated in a water bath for five, ten, fifteen, twenty, and twenty-five minutes at 58° C. The tube that was heated for twenty-five minutes remained clear. All of the others, including check, developed pure cultures of this bacillus.

PATHOGENIC PROPERTIES.

In the detailed account of the isolation and differentiation of this bacillus, its effect upon rabbits was partially described. The germ (the one from the spleen) was preserved by means of subcultures until September (eight months), when a series of inoculations were made which demonstrated more fully the range of its pathogenic effect. Rabbits inoculated subcutaneously with 0.01 cc. of a bouillon culture died in from four to six days. The lesions were marked necrosis in the liver, enlarged and discolored spleen, heart muscle pale. In some cases Peyer's patches were pigmented and the kidneys more or less hyperæmic. Occasionally a few shreds of exudate over the intestines, but no bacteria present as indicated by cover-glass preparations. The organs contained very few elongated oval bacteria which exhibited a light unstained center and deeply stained periphery in cover-glass preparations. This was true in similar preparations from other animals. An intravenous inoculation of the same quantity proved fatal in about forty-eight hours. Guinea pigs were destroyed in eight days by a subcutaneous injection of 0.03 cc. of a bouillon culture. The lesions were similar to those produced by hog cholera bacteria. Mice perished in six days after a subcutaneous injection of from one to two drops of a bouillon culture.

A pig weighing 50 pounds, inoculated intravenously with 6 cc. of a four-day bouillon culture, died on the afternoon of the second day. The lesions were not distinguishable from those produced by a similar inoculation of strong hog cholera virus. Pure cultures were obtained from the different organs.

A rabbit that had been made immune to swine plague was inoculated subcutaneously, together with a check rabbit, with 0.01 cc. of a bouillon culture. The check died in four days. The treated rabbit perished on the sixth day, two days later than the check. This is interesting, as rabbits that have been made immune to swine plague offer no resistance whatever to hog-cholera bacteria.

In June, 1892, this bacillus was as fatal to rabbits as in September,

1891. This is important in differentiating it from certain so-called toxicogenic bacteria that have been found in water and in diseased animal tissues which were fatal to rabbits when first isolated, but which soon lost their virulence.

From the description of the various properties of this bacillus it will be observed that it resembles the hog-cholera bacillus in (1) its biological characters; (2) the light center and deeply stained periphery in cover-glass preparations;* (3) the appearance of the bacteria in pairs in preparation from animal tissues, and (4) the character of the lesions produced in experimental animals. It differs from it in (1) morphology, (2) its feeble resistance to drying, (3) the small number of bacteria present in the tissues of animals dead from its inoculation, and (4) it is more rapidly fatal to rabbits. Its non-motility, however, is the only *specific* difference that can be considered between it and the bacillus of hog cholera. Cultures on the various media have been very carefully examined in the very early and advanced stages for the purpose of determining whether or not this germ was motile under any of the ordinary conditions of cultivation, or at any age of the culture, but only negative results were obtained. No flagella could be found, although a very careful examination was made in which the same methods were employed that were satisfactory in demonstrating the flagella on the hog-cholera, coli, and typhoid bacilli. As flagella can be demonstrated on motile but not on non-motile bacteria, it seems fair to presume that after these tests this bacillus can be safely considered a non-motile organism.

Although morphologically it resembles the swine-plague group of bacteria its cultural characters and pathogenic effect on animals differentiate it very distinctly from that group of organisms. The differences between it and the swine-plague and hog-cholera bacteria appear to be sufficiently great to consider it a species rather than a modified form of either of the specific disease germs. Further investigations, however, may reveal intermediate forms which will connect it unquestionably with one or the other of these specific bacteria. The close resemblance that exists between these organisms suggests the importance of a thorough examination of all of the various properties of a germ before it is placed unreservedly in any species, and especially so in cases of pathogenic organisms where a description based on incomplete observations may lead to unexplainable differences in the correlation of our disease-producing bacteria.

* In the earlier investigations of hog cholera (Second Annual Report Bureau of Animal Industry, U. S. Department of Agriculture, 1885, p. 212) this reaction of the bacteria to the staining fluids was very constant. It is not, however, so universally observed in the bacteria that have been isolated from more recent outbreaks, although it is frequently noticed. The difference may be due to slight variations in the germs themselves, or to some inappreciable difference in the staining fluids or mode of their application.

From a bacteriological standpoint the natural habitat of this bacillus is of much interest. The fact that it has not heretofore been observed would indicate that it does not belong to the normal flora of the lungs. As it was the predominating form in the bronchial secretions, it is presumable that it first gained entrance to the air passages, from which it invaded the inner organs of the body. Although it was universally fatal to experimental animals, there is very little if any evidence that it was to any degree responsible for the death of the pig from which it was obtained. This fact renders it of little economic importance when considered with reference to this case alone, but it seems reasonable to suppose that a germ which possesses such marked pathogenic properties might, under certain conditions, be the cause of a more or less serious outbreak of infectious disease.

PATHOGENIC AND TOXICOGENIC BACTERIA IN THE UPPER AIR PASSAGES OF DOMESTICATED ANIMALS.

By VERANUS A. MOORE.

In 1888 Dr. Theobald Smith* demonstrated the fact that in the secretions covering the posterior nares, pharynx and larynx of certain numbers of apparently healthy pigs, were bacteria, which could not be distinguished either by their cultural characters or in their pathogenic properties from the swine-plague germs. In an appendix to the same report are the results of a few preliminary examinations of the secretions from the upper air passages of certain other domesticated animals which I made for the purpose of determining the extent of the distribution of these bacteria. In these investigations it was found that similar bacteria were present in the secretions covering the mucosa of the upper air passages in certain numbers of such animals as cattle, dogs, and cats. Since the publication of that report, further examinations have been made, from time to time, from both the same and other species of animals. As a final result of these observations the swine-plague group of bacteria was found to be present, apparently in its natural habitat, in the upper air passages of a certain per cent of healthy pigs, cattle, cats, dogs, and horses. In sheep very attenuated forms were occasionally found. Pathogenic bacteria were not discovered in the flora of the mucosa of healthy rabbits, fowls, and guinea pigs. A few examinations were also made from frogs and turtles, but with negative results.

The method that was employed in the latter examinations is the same as that used in the earlier investigations, viz, the subcutaneous inoculation of rabbits with the secretions taken from the mucosa of the upper air passages of the living or freshly killed animals. It is given in detail in the report on swine plague (*l. c.*, p. 110), and consequently need not be repeated here.

The pathogenic bacteria previously reported from the healthy mucosa of the different species of animals could not be distinguished from the swine-plague group, and only slight variations were found to exist between the germs isolated from the various animals, either of the same

*Report on the Cause and Prevention of Swine Plague. U. S. Department of Agriculture, 1891, p. 109.

or different species. The more recent investigations, however, have revealed the existence of bacteria which vary in a marked degree from the more typical swine-plague germ, and also the presence of toxicogenic bacteria which are widely separated from the swine-plague group of organisms.

The total results, as reported in 1891, are, for the sake of comparison, tabulated here. As previously stated, all the pathogenic bacteria which were obtained could not be distinguished from the swine-plague germs. They varied from the rapidly fatal septicæmia forms which destroyed rabbits in sixteen hours when inoculated subcutaneously, to those that possessed so little virulence that thirteen days were required for the rabbits to die.

Table showing the species of animals from which rabbits had been inoculated and the results reported up to 1891.

Species of animals.	Number of animals from which rabbits were inoculated.	Swine-plague bacteria present in.	Number pathogenic bacteria not found in.	Per cent normally infected.	Virulence of the germs.
Pigs	19	5	14	26	Attenuated.
Cattle	7	5	2	71	Do.
Cats	7	6	1	85	Very virulent and attenuated.
Dogs	6	2	4	33	Virulent.
Horse	1	.....	1	.....	No pathogenic bacteria.
Sheep	1	.....	1	.....	Do.
Fowls	2	.....	2	.....	Do.
Rabbit	1	.....	1	.....	Do.

In addition to the inoculations from pigs which were reported, another series was made which gave uniformly positive results. The bacteria, however, as in the other cases were attenuated, producing in the rabbit more or less cellular infiltration with the localization of the bacteria on one or more of the serous membranes. The facts necessary for an understanding of these inoculations are given in the appended table:

Inoculation of rabbits with the mucus from the upper air passages of pigs.

Pig No.	Mucus from—	Rabbit inoculated.	Date of inoculation.	Rabbit died in—	Remarks.
		No.		Days.	
181	Larynx...	1	Sept. 23, 1889	2	Local reaction; peritonitis.
		2	do	2	Do.
267	Trachea ..	3	Jan. 2, 1890	5	Do.
		4	do	6	Local reaction; hemorrhages in cæcum.
303	Pharynx...	5	Jan. 28, 1890	3	Local reaction; peritonitis.
		6	do	4	Do.
305	Larynx...	7	do	4	Do.
		8	do	5	Local reaction; hemorrhagic areas in cæcum.
308	Pharynx...	9	Feb. 11, 1890	4	Local reaction; peritonitis; pleuritis.
		10	do	5	Do.
219	do	11	Feb. 14, 1890	3	Do.
		12	do .....	.....	Remained apparently well.
202	Larynx...	13	do	4	Local reaction; peritonitis; hemorrhages in cæcum.
		14	do	4	Local reaction; pleuritis.
7	do	15	Apr. 2, 1890	4	Local reaction; peritonitis; hemorrhages in cæcum.

The pigs from which these inoculations were made came from different herds, excepting Nos. 181 and 305. These were secured from the same farm with an interval of nearly nine months between the times of purchase. The inoculations were made in a few cases as soon as the pigs were purchased, but in other instances they were kept at the Experiment Station for a greater or less period of time prior to the examination. The uniform positive results obtained in this series would indicate a more general distribution of the swine-plague group of bacteria in the flora of the upper air passages of healthy pigs than would be supposed from the previously reported results.

In the consideration of the more recent rabbit inoculations from the various animals, a table has been constructed for each of the species examined. Very few additional examinations have been made from those species from which a considerable number of examinations were heretofore reported. It seemed, for obvious reasons, more desirable to obtain the secretions from freshly killed animals, and on this account the work has extended over a considerable length of time in order to obtain the secretions from suitable animals that were killed for other and more important purposes. In a few instances the cattle and sheep were slaughtered at the abattoir for beef and mutton. I am indebted to Dr. F. L. Kilborne, Director of the Experiment Station, for assistance in making many of the inoculations.

INOCULATIONS FROM CATTLE.

Rabbits have been inoculated with the secretions from the upper air passages of three animals. Two of these (Nos. 8 and 9), were from the Experiment Station, and the other (No. 10) was a steer killed at the abattoir for beef. No. 8 died of Texas fever. The mucus was taken from the amygdaloid cavities very soon after death. This fact does not detract from the justice in using this animal, as the disease from which she suffered was not bacterial in its nature. The subjoined table is self-explanatory:

Inoculation of rabbits with the mucus from the upper air passages of cattle.

Animal No.	Mucus from—	Rabbit inoculated.	Date of inoculation.	Rabbit died in—	Remarks.
		No.		Days.	
8	Amygdaloid cavities..	27	Aug. 27, 1891	2	Local reaction, spleen, liver, and kidneys hyperemic.
	do.....	28	do.....	2	Local reaction, peritonitis.
9	do.....	29	May 13, 1892	15	Severe local reaction, spleen and liver hyperemic.
10	Larynx.....	30	June 2, 1892	5	Severe local reaction, thoracic and abdominal organs normal, cultures remained clear.

The bacteria * obtained from rabbits inoculated from cow No. 8 could

*The various morphological, biological, and pathogenic properties of these bacteria will not be mentioned excepting where they differ from the descriptions published in the previous report (*l. c.*) or where additional facts concerning any of these properties have been obtained.

not be distinguished from the swine-plague germ in their morphology, biological characters, or pathogenic properties. They gave the phenol reaction, but no trace of indol could be found. They perished after drying on cover-glasses for twenty-four hours, and were destroyed by heating at a temperature of 60° C. in a water bath for ten minutes.

In order to compare more fully the pathogenic effect of these bacteria with that of the swine-plague germ a pig was inoculated with a culture from rabbit No. 27. The facts concerning the inoculation and its results are as follows:

October 16, 1891.—Pig No. 39, weighing about 25 pounds, was inoculated with 5cc. of a fresh bouillon culture in a subcutaneous vein in the right thigh.

October 17.—Pig barely able to stand.

October 19.—Pig down, unable to rise; ate very little.

October 20.—Pig lies on one side, can not be roused up; refuses food.

October 26.—The pig still refuses food. Metatarsal joints considerably swollen. It breathes with apparent difficulty.

October 27.—No appreciable difference in its condition. It was killed by a blow on the head.

Post-mortem examination.—The skin over the ears and above the eyes and nose was of a purplish color; a small amount of subcutaneous fat. Both metatarsal joints and right elbow joint swollen, fluctuation detected. Subcutis about these joints oedematous. The sections showed the joint capsules to contain a considerable quantity of thick, greenish-yellow, semi-solid substance. About the edges of the joint cartilages were small pockets of pus. The suppuration extended from the capsule between the muscles for from 1 to 2 inches. Spleen slightly enlarged, pulp firm. Liver slightly discolored, fatty, contained several cysts of *Tænia echinococci*.* The gall bladder contained a small quantity of very thick, yellowish-brown bile which could not be forced through the duct. Kidneys, cortex pale (parenchymatous degeneration), pyramids of a glairy, reddish appearance. Capsule easily removed. Stomach contained no food; a small quantity of bile-stained mucus in pyloric end. Mucosa pale. Small intestines contained bile-stained mucus; mucosa slightly reddened from injected blood vessels. Lymphatics pale and oedematous throughout. Lungs partially collapsed, deeply congested, but no hepatization or hemorrhages. Heart muscle very pale.

Stained cover-glass preparations from the blood, spleen, liver, and pus from elbow joint showed no bacteria. Similar preparations from the kidneys exhibited a large number of oval bacteria, many of which took the polar stain. Tubes of agar and bouillon inoculated from the blood and spleen remained clear. Those inoculated from the liver, kidneys, and pus from the affected joints developed pure cultures of bacteria which were not distinguishable from the swine-plague germ.

A rabbit was inoculated subcutaneously with a bit of the pus from one of the metatarsal joints. It perished on the third day with lesions characteristic of attenuated swine plague.

The suppurative condition of the joints which formed the most marked lesion is not unlike that found by Dr. Smith in pigs inoculated intravenously with swine-plague bacteria (*l. c.* p. 75). The resemblance of this germ to that of bovine pneumonia is worthy of careful attention.

In the rabbit inoculated from cow No. 9 there was a marked difference. It lived for an unusually long period after the inoculation. The

*This appears to be the first time that this parasite has been found in pigs from the District of Columbia.

subcutaneous and intermuscular tissue was infiltrated with a purulent substance over the entire abdomen and thorax. The abdominal organs were hyperæmic but no exudate. Cover-glass preparations revealed the presence of no bacteria, but culture media inoculated from the spleen and blood developed feeble growths of an elongated non-motile bacillus, which will be briefly described under the provisional name of bacillus No. 1.

BACILLUS NO. 1.—*Source:* From the spleen and blood of a rabbit inoculated with the mucus from the amygdaloid cavities of cow No. 9. *Morphology:* A non-motile oval bacillus 1.5 to 2.0 μ in length. Stains deeply or with a light center. Polar arrangement of the cellular protoplasm well marked when examined at the edge of a hanging drop preparation. *Biology:* On the surface of agar it develops a somewhat vigorous grayish, non-viscid growth. Growth very feeble in gelatine. It does not develop on potato. Bouillon becomes very faintly clouded with an acid reaction. In peptonized bouillon containing 2 per cent glucose in a fermentation tube it imparts a uniform cloudiness to the liquid throughout the tube. It ferments the sugar with the production of a large quantity of gas (five-ninths of the contents of the tube) one-third of which was absorbed by potassium hydrate. Milk was thickened in twenty-four hours, not viscid. *Pathogenesis:* Rabbits inoculated with 0.5 cc. of a fresh bouillon culture exhibited an elevation of temperature which lasted for about five days. Otherwise they appeared to be unaffected.

Rabbit No. 30, inoculated from cow No. 10, exhibited an extensive purulent infiltration and sanguinolent effusion in the subcutaneous tissue over the entire ventral aspect of the body. No bacteria were found in the organs, but cover-glass preparations from the local lesion contained a very large number of oval elongated bacteria, resembling those isolated from rabbit No. 29. Unfortunately no cultures were made from the local lesion and those made from the spleen and blood remained clear.

INOCULATIONS FROM SHEEP.

The sheep from which secretions were obtained were killed in part for mutton at the abattoir and in part for various purposes at the Experiment Station. In the examinations that have thus far been made no bacteria have been found which were identical in their various properties with the swine-plague group of organisms. The facts necessary for an understanding of these inoculations are tabulated below.

Inoculation of rabbits with the mucus from the upper air passages of sheep.

Sheep No.	Mucus from—	Rabbit inoculated.	Date of inoculation.	Rabbit died in—	Remarks.
		No.		Days.	
2	Larynx and pharynx.	33	Nov. 6, 1891	10	Severe local reaction; bacteria from local lesions only.
3	do.....	34	do.....	.....	Killed after thirty-two days; no bacteria.
3	Mouth	35	May 26, 1892	18	Local abscess; oval bacteria from local lesion only.
4	do.....	36	do.....	19	Severe local reaction; no pathogenic bacteria.
5	do.....	27	do.....	.....	Rabbit remained well.
6	Pharynx and larynx.	38	May 28, 1892	22	Slight local reaction; many coccidia in liver, no bacteria.
	do.....	39	do.....	.....	Rabbit remained well.

Rabbit No. 33 exhibited an extensive purulent infiltration in the subcutaneous tissue over the ventral aspect of the body, starting from the point of inoculation. The thoracic and abdominal organs were apparently normal. No bacteria were found in cover-glass preparations made from the spleen and blood. A large number of oval, elongated bacteria were present in similar preparations from the local abscess. Cultures from the spleen and blood remained clear. A tube of bouillon inoculated from the local abscess developed an impure culture of a bacillus resembling morphologically the swine-plague germ. The other rabbit was killed after thirty-two days. No lesions.

A rabbit was inoculated subcutaneously with 0.50 cc. of a bouillon culture of the germ made directly from the local abscess of rabbit No. 33. It perished on the second day. It exhibited slight local reaction; liver large, hyperæmic. Spleen slightly enlarged. No localization of bacteria on serous membranes. Bacteria appeared in cover-glass preparations from the liver as deeply stained bodies. No polar stain observed. Similar preparations from the spleen and blood exhibited no bacteria. Tubes of bouillon inoculated with bits of the liver developed pure cultures of a non-motile bacillus 1.5 to 2.5 μ in length; ends rounded. At the edge of a hanging drop preparation the cell protoplasm was observed to be more dense at the poles or extremities. Many of them exhibited the polar stain. The periphery stained more deeply than the center. The cultures from the spleen and blood remained sterile. This bacillus differed very slightly from the swine-plague germ in its biological properties.

The rabbit inoculated from sheep No. 4 presented on post-mortem examination an extensive purulent infiltration into the subcutis. No inflammation of the serous membranes. From the local lesion cultures of an elongated, oval germ were obtained which subsequently destroyed a rabbit in three days when inoculated subcutaneously with 0.75 cc. of a pure bouillon culture. It exhibited a local reaction, but no localization of the bacteria on the serous membranes. This germ differed from the swine-plague organism in (1) not exhibiting a polar stain in cover-glass preparations from the organs of the rabbit; (2) it was slightly larger; (3) the growth on the agar was not viscid, and (4) its localization at the place of inoculation only.

Rabbit No. 36 perished evidently from the effect of the local reaction, which was extremely severe. A micrococcus which grew in clumps was isolated from the infiltrated substance, but it possessed no pathogenic properties, as indicated by an intravenous inoculation in rabbits. Rabbit No. 38 perished presumably from the effect of the coccidia in the liver.

Although the bacteria isolated from the air passages of sheep differed in a marked degree from each other, and from the swine-plague germs in their virulence and pathogenic manifestations, their general morphological and biological characters would indicate that they

belong to that group of organisms. The severe purulent infiltration into the subcutaneous tissue, extending from the point of inoculation, was undoubtedly partially due to other germs that were introduced with the mucus. The non-localization of the bacteria on the serous membranes is the most important variation that was found to exist between these and the attenuated swine-plague bacteria.

INOCULATIONS FROM HORSES.

Rabbits were inoculated with the secretions from the upper air passages of five horses. Two of these were the work horses at the Experiment Station. The other three were from Washington, D. C., two of which were killed for lameness. The following table is self-explanatory:

Inoculation of rabbits with the mucus from the upper air passages of horses.

Horse No.	Mucus from—	Rabbit inoculated.	Date of inoculation.	Rabbit died in—	Remarks.
		No.		Days.	
2	Trachea	42	June 24, 1891	5	Spleen enlarged; streptococci from organs.
	Larynx	43	do	9	Slight local reaction; peritonitis; polar-stained bacteria.
3	Root of tongue..	44	May 26, 1892	.....	Rabbit remained well.
	Nares	45	Apr. 23, 1892	.....	Do.
		46	do .....	.....	Do.
5	Pharynx	47	Mar. 8, 1892	.....	Do.
	Root of tongue..	48	Apr. 7, 1892	26	Rabbit emaciated; no bacteria.
6		49	do .....	.....	Rabbit remained well.
		51	do .....	.....	Do.

The inoculations with the mucus from horses showed the flora of their mouth, nose, and throat to be comparatively free from pathogenic bacteria. No. 2, however, was unusually fertile in these forms. Rabbit No. 42 died evidently from the effect of a streptococcus which was isolated from its organs. This germ was rapidly fatal to rabbits and mice; 0.10 cc. of a bouillon culture destroyed a rabbit, when inoculated subcutaneously, in less than two days. In cover-glass preparations from the organs of the rabbit it appeared very largely in single forms, frequently, however, in very short chains. The individual segments were elongated and frequently exhibited a polar stain. The resemblance of the individual elements to the swine-plague germ was very marked. This was true of its biological properties. It became much attenuated in about nine months. This germ is described more fully under the name "Streptococcus U," in the article on Streptococci.

Rabbit No. 28 presented lesions typical of attenuated swine plague. Its organs contained bacteria that could not be differentiated from the swine-plague germ.

A rabbit inoculated subcutaneously with 0.10 cc. of a bouillon culture died on the third day with severe local reaction, but no marked localization of the bacteria on the serous membranes. No phenol or indol reaction could be detected in bouillon cultures of this germ. Its power

to resist drying and its thermal death point were not appreciably different from those of the swine-plague germ.

Rabbit No. 33 perished presumably from the effects of the inoculation, but no bacteria could be found in any of the organs. The other rabbits remained well.

INOCULATION OF GUINEA-PIGS FROM THE NASAL DISCHARGE OF A MULE.

September 10, 1892, Dr. F. L. Kilborne inoculated a guinea-pig with mucus from the nose of a mule which was suspected of having glanders. The guinea-pig was found dead September 12. From the organs cultures of bacteria were obtained which were fatal to rabbits in from two to four days. They were not distinguishable from the swine-plague germ in their biological and pathogenic properties. In cover-glass preparations from tissues, however, they did not exhibit the polar stain.

September 12 a second guinea-pig was inoculated from the same mule. It died September 14. Tubes of bouillon inoculated from the organs developed pure cultures of the *Bacillus fluorescens liquefaciens*. A rabbit inoculated subcutaneously with 0.75 cc. of a bouillon culture of this bacillus perished in forty hours. At the point of inoculation there was an infiltration of serum into the subcutaneous tissue. Abdominal organs hyperæmic. Cover-glass preparations from the spleen and liver contained many bacilli. Pure cultures were obtained from the spleen and liver. A rabbit inoculated in the ear vein with 0.10 cc. of a fresh bouillon culture perished in seven days. After three weeks cultivation this germ lost its virulence to such an extent that 0.75 cc. produced no effect on rabbits. This is the first time, so far as I am aware, that this bacillus has been reported as possessing pathogenic or septic properties.* It did not produce gas. When grown in the fermentation tube it developed in the open bulb only.

INOCULATIONS FROM CATS.

Rabbits have been inoculated with the mucus from the upper air passages of three healthy cats, all of which contained bacteria which belong to the swine-plague group of organisms. The facts concerning these inoculations are tabulated below.

* In the summer of 1892, while making a series of inoculations in pigeons with another germ, the cultures became contaminated with the *Bacillus fluorescens liquefaciens*. It was isolated by means of agar plate cultures and a pigeon inoculated in the pectoral muscle with 0.50 cc. of a pure bouillon culture. The pigeon died in forty hours with extensive necrosis of the pectoral muscle. Heart muscle pale. Many bacilli were found in cover-glass preparations from the organs. A second pigeon, inoculated with 0.50 cc. of an emulsion of the pectoral muscle from the first pigeon, remained well.

Inoculation of rabbits with mucus from the upper air passages of cats.

Cat No.	Mucus from—	Rabbit inoculated.	Date of inoculation.	Rabbit died in—	Remarks.
		No.		Hours.	
8	Larynx.....	63	Aug. 31, 1890	21	Septicemia.
		64	Aug. 31, 1890	21	Do.
9	Trachea and larynx.	65	Sept. 4, 1892	20	Do.
10	Pharynx and larynx.	66	May 31, 1892	48	Local reaction; peritonitis.

The bacteria obtained from cat No. 8 by rabbit inoculation was compared very carefully with the germs of acute swine plague. They gave in bouillon (containing 1 per cent peptone) cultures 22 days old a decided phenol reaction, but no trace of indol could be found. Their power to resist drying and their thermal death point were identical with those of the swine-plague germ.

The pathogenic power of these bacteria was tested by a pig, guinea-pig, and rabbit inoculations.

October 16, 1891.—A pig weighing about 30 pounds was inoculated in the vein (inside of right thigh) with 5 cc. of a fresh bouillon culture. It was found dead on the morning of October 17, twenty-four hours after its inoculation. The abdominal organs were slightly hyperæmic, lymphatic glands reddened. About 100 cc. of a clear straw-colored serum in the right pleural cavity, a smaller quantity on the left side. Beneath the pleura over the lungs were several irregular areas containing petechiæ. Lungs not collapsed. Slight emphysema. Cover-glass preparations from the organs contained very many polar-stained, oval bacteria.

A pig inoculated at the same time, and with a similar quantity of a like culture of virulent swine-plague bacteria, perished at the same time and with similar lesions.

A guinea-pig inoculated subcutaneously with 0.001 cc. of a bouillon culture perished on the tenth day. It exhibited considerable cellular infiltration into the subcutis, involving the superficial layer of the subjacent muscle. The abdominal organs were covered with a cellular, pasty exudate. There was beginning pleuritis as exhibited by a large number of bacteria in cover-glass preparations made by drawing a cover-glass over the surface of the visceral pleura. A guinea-pig inoculated with a similar quantity of a like culture of a virulent swine-plague germ recovered after some weeks. This fact would indicate a slight increase in the virulence of the tracheal germs over that of the swine-plague organism used.

They destroyed rabbits in about sixteen hours. In cover-glass preparations from their organs the bacteria were appreciably larger than the swine-plague germ. They appeared frequently in clumps, and when stained were separated by unstained septa, which suggested the possibility of a capsule. There were many involution forms, in some of which the cellular protoplasm was condensed near the center of the cells rather than at the ends as indicated by their reaction to the staining fluids.

The bacteria from cat No. 9 differed from those from cat No. 8, in that they were larger, did not exhibit the polar stain (excepting involution forms), and were localized more especially in the liver of the rabbit.

Rabbit No. 66 exhibited lesions characteristic of attenuated swine plague.

The almost uniform presence of the swine plague group of bacteria in the normal saliva of cats is of considerable interest, inasmuch as these animals are so largely the living pets of children and the effect of these germs on the human species is not yet demonstrated. Their effect on the smaller experimental animals, however, does not differ, to any marked degree, from those of the germs of pneumonia in man.

Fiocca* has recently described a pathogenic bacillus which he found in the saliva of cats and dogs, and which resembles the germ of rabbit septicæmia, but only one-half its size. The variation which I have found in the size of the bacteria from the saliva of cats would indicate that Fiocca's germ belongs to the same group of bacteria as those which I have found in these animals. It will be observed that there is a considerable variation in both the morphology and virulence of the pathogenic bacteria found in the upper air passages of apparently healthy cats.

OTHER INOCULATIONS.

Rabbits were inoculated with the secretions from the pharynx, larynx, or trachea of one healthy dog, six rabbits, five guinea-pigs, and four fowls, with negative results.

It is of further interest to note that pathogenic bacteria were not discovered in the flora of the upper air passages of rabbits, guinea-pigs, and fowls, although it frequently happens that these animals perish from sporadic diseases, the lesions of which resemble those produced by the inoculation of the swine-plague germ, and that bacteria which belong to the swine-plague group can be isolated from the affected organs. On the other hand it should be mentioned that cats are immune to large doses of the virulent swine-plague germ.

From the results recorded in the preceding pages it is found that 48 per cent of pigs,† 80 per cent of cattle, 50 per cent of sheep, 16 per cent of horses, 90 per cent of cats, and nearly 30 per cent of dogs contain among the flora of their upper air passages bacteria which possess more or less pathogenic or septic properties. Of these the greater number belong to the swine-plague group, and can be designated as pathogenic bacteria, while the other forms which possess only temporarily destructive power appear to more properly belong to the toxicogenic bacteria. The extremely attenuated forms from the sheep and the great variation found in the pathogenic properties of those from

*Centralblatt f. Bakteriologie u. Parasitenkunde, Bd. XI, 1892, p. 406.

†This is based upon both my own results as recorded in the table and those heretofore published by Dr. Smith.

the cats are interesting in showing the graduation of the swine-plague group of bacteria from the very virulent to the extremely attenuated forms.

The close resemblance of the pathogenic bacteria to the swine-plague germs has been determined by a large number of inoculations and parallel cultures, and by a careful study of their morphology in both fresh and stained preparations. Their feeble power to resist drying and their thermal death point are identical with those of the virulent swine-plague bacteria.

Bacillus No. 1 from cow No. 9 is interesting, from the fact that while it resembles in its general morphological characters the swine-plague germ, it possessed the property of fermenting sugar with the formation of gas. These variations are important in the classification of disease-producing bacteria. The streptococcus isolated from the nares of a healthy horse differed very slightly in its more hardy biological characters, as well as in its effect upon certain animals from the description of the streptococcus which has been described as the supposed cause of strangles.

The very general distribution, in the secretions covering the mucosa of the upper air passages of domesticated animals, of bacteria which possess such marked pathogenic and toxicogenic properties, is of much importance, as it explains the cause of sporadic cases of swine-plague,* and, to some extent at least, the possible source and significance of various toxicogenic bacteria which are frequently isolated from variously diseased animal tissues.

* For a discussion of the relation of these bacteria to isolated cases of pneumonia in swine, see Dr. Smith's Report on Swine Plague, *l. c.*, pp. 109-117.

AN OUTBREAK OF ABORTION IN MARES.

By F. L. KILBORNE.

During the winter of 1890-'91 an outbreak of abortion occurred among the mares of a large stud near Franklin, Pa. On visiting the farm February 5, 1891, I found the stud to comprise about one hundred brood mares and several stallions.

The first mare to abort, due to foal March 21, dropped her foal December 2, or 109 days before full term. Between December 2 and February 5, ten abortions occurred, at periods ranging from 23 days to 195 days, or an average of 100 days, before the completion of the period of gestation. No history of any introduction of the infection from without could be obtained beyond the fact that mares were daily being received at the stock farm from various parts of the State, to be bred to the stallions of the stud. But as far as could be ascertained no mare had been received from any stable in which abortions had previously occurred.

The brood mares were all kept in box stalls, bedded with peat moss, on a dirt floor. The box stalls were arranged in one row around the outside of the barn, and another within. Between the two rows there was a tan-bark track for exercising the animals. The barn was rather damp, but otherwise apparently well suited to the purpose. Each pregnant mare received, on an average, about 6 quarts of oats and a little bran, with a moderate allowance of timothy hay, daily. Mares in poor condition received more, while those in high condition were fed less. The mares were exercised daily, by being ridden on the tan-bark track.

The veterinarian in charge of the stables had taken the usual precaution of removing the aborting mares as soon as discovered, and disinfecting the stall. Such mares were disinfected per vaginam by repeated injections of a diluted solution of corrosive sublimate, 1 part to 10,000 of water, and the external organs, tail and hind limbs sponged over with a stronger solution, 1 part to 1,500 of water. The stable had also been repeatedly fumigated with burning sulphur. Fluid extract of black haw (*Viburnum prunifolium*) in half ounce doses once daily, had been given the pregnant mares during the month preceding February 5.

At the time of the above visit there had been no indications of another abortion during the past week, the last abortion having occur-

red January 29. In order to guard against a continuation of the outbreak, a more thorough system of disinfection of the whole stable was advised and carried out. For this purpose a 2 per cent solution (by volume) of commercial sulphuric acid was used. All stalls were to be disinfected once a week, and any stall occupied by a mare aborting was to be immediately vacated, thoroughly cleaned and disinfected.

The practice of exercising the mares by riding was discontinued, and they were exercised by being led at the halter. On account of the extreme cold weather the drinking water was to be given in quantity not to exceed one-half horse-bucketful at one time, and with the chill taken off. All pregnant mares were to have the tail and external genital organs sponged over daily with a solution of the mercuric chloride 1 part to 1,000 or 1,500 of water. The fluid extract of black haw was continued throughout February, but apparently without result. The mares aborting February 15 to March 4, were among the number receiving the extract.

From January 29 until February 15, no abortions occurred; but from this date until March 4 six mares aborted. A second visit was made to the farm at this time. The additional precautions taken during the past month having failed to check the outbreak, it was deemed advisable to remove all the pregnant mares from the large barn to other stables. Accordingly eighteen of the remaining mares were removed to a stable, formerly used only for colts, with high plank floor and roomy box stalls. The other mares were to be removed as soon as accommodations could be provided for them. Owing to some delay of the carpenters in completing another stable, these mares were not removed from the large barn as intended.

In the barn to which the eighteen mares were removed, all stalls were to be entirely emptied of bedding, and swept and sprinkled with 2 per cent solution of sulphuric acid, twice a week. The disinfection of the large barn was continued as before. All pregnant mares continued to have the root of tail and vulva washed, once daily, with the mercuric chloride solution. In washing, the lips of the vulva were pressed apart with the sponge in order that the solution might be worked in as far as possible. In attempting to inject a diluted solution, even a short distance into the vagina, it was found to produce more or less straining, and was therefore discontinued.

Beginning with March 4, one-half of the mares were to receive the fluid extract of black haw, in doses of one-half ounce once daily; the remaining half of the mares to receive one heaping tablespoonful of the following powder in the feed twice daily, omitting the powders for four or five days after each two weeks: Chlorate of potash, phosphate of soda, of each 1 pound; sulphate of quinine 3 ounces, mix. This treatment was continued to the end of the season. No further abortions occurred.

From the last case to abort, in the evening of March 3, cultures were made on agar-agar early the following morning. The cultures were made by separating the lips of the vulva as far as possible, and lightly

scraping the mucosa of the vulva with a flamed platinum loop and rubbing this upon the inclined agar surface. In these tubes a bacillus appeared, which is described in an article by Dr. Smith, following this account.

Table showing date of abortion and stage of gestation of each mare aborting.

Number of mare.	Due to foal.*	Aborted.	Number of days before close of normal period.	Horse by which mares were in foal.
1.....	Mar. 21, 1891	Dec. 2, 1890	109	No. 1.
2.....	Apr. 14, 1891	Jan. 5, 1891	99	No. 1.
3.....	Feb. 13, 1891	Jan. 21, 1891	23	No. 1.
4.....	Apr. 5, 1891	Jan. 23, 1891	72	No. 2.
5.....	May 6, 1891	Jan. 23, 1891	101	No. 3.
6.....	May 1, 1891	Jan. 26, 1891	95	No. 1.
7.....	Apr. 26, 1891	Jan. 27, 1891	89	No. 1.
8.....	June 12, 1891	Jan. 27, 1891	136	No. 4.
9.....	Aug. 11, 1891	Jan. 28, 1891	195	No. 2.
10.....	Apr. 24, 1891	Jan. 29, 1891	85	No. 1.
11.....	Apr. 24, 1891	Feb. 15, 1891	90	No. 1.
12.....	June 2, 1891	Feb. 17, 1891	105	No. 1.
13.....	May 14, 1891	Feb. 20, 1891	83	No. 5.
14.....	Apr. 15, 1891	Feb. 24, 1891	50	No. 6.
15.....	Aug. 25, 1891	Feb. 28, 1891	178	No. 1.
16.....	July 4, 1891	Mar. 3, 1891	123	No. 2.

* Eleven months allowed as period of gestation.

Of the sixteen mares nine were in foal by stallion No. 1; three by stallion No. 2, and one each by four other stallions.

Mare No. 5 died after the abortion. The others all made a good recovery. No. 7, however, was a chronic aborter, having lost two or three foals previously.

There still remained, March 4, thirty-six pregnant mares, due to foal March 19 to September 14. Two mares due to foal February 18 and 26, making bag. Live foals at term were dropped February 2 and 11, and March 4. One dead foal dropped at term February 19.

In the fall of 1891, when the mares were first brought in from the pasture, three abortions occurred in a small barn where several mares were kept. The aborting mares were at once isolated and the stalls disinfected with the solution of sulphuric acid. The pregnant mares were again given the fluid extract of the black haw in half-ounce doses, once daily, and the vulva and root of tail washed with mercuric chloride solution, as before. No further abortions occurred during the season of 1891-'92.

In order to test the pathogenic properties of the bacillus obtained from mare No. 16, and described by Dr. Smith, vaginal injections were made with pure cultures on one pregnant mare and two pregnant cows. Inoculations were also made on two pigs.

Vaginal injection of pregnant mares.—On April 22 a large bay mare, age 7 years, supposed to be in the ninth month of gestation, received by injection into the vagina 10 cc. of a peptone bouillon culture, two days old, of the bacillus. Twenty-four hours after the injection an abundant, purulent discharge of a grayish-white color was

coming from the vagina. This discharge continued for two days, after which it ceased. The mare developed well-marked symptoms of influenza on the day following the injection, and from April 23 to 30 suffered a severe attack, with a temperature varying from 102.4° F. to 106.2° F. There were several cases of influenza in the stable from which the mare came, so that it is evident the mare contracted the disease before coming to the station. On May 2 the mare dropped a live foal, probably owing to the attack of influenza. The birth was evidently premature, as shown by the lack of development and weakness of the colt, which lived but two days.

Vaginal injection of pregnant cows.—On April 11 a two-year-old heifer, No. 160, and a cow, No. 152, five years old, were chosen for the injection. No. 160 was supposed to be in the seventh or eighth month of pregnancy, while No. 152 was in the fifth month, having taken the bull November 29, 1890. Each cow received by injection into the vagina 10 cc. of a peptone bouillon culture of the bacillus twenty-four hours old. Twenty-four hours after the injection there was quite an abundant, purulent discharge of a dirty grayish-white color from the vagina of both cases. After two days this discharge gradually diminished and had entirely ceased April 15. On April 22 both cows were given a second vaginal injection of a similar culture of two days' growth. No. 152 received 10 cc. as before, and No. 160 received 25 cc. Twenty-four hours after the injection No. 152 showed a slight vaginal discharge, and No. 160 a much more abundant discharge of the same character as before. The discharge had entirely ceased on the third day.

Below is given the temperature of the two cows taken morning and evening during the period of injection:

Date.	Cow No. 160.*		Cow No. 152.	
	9 a. m.	5 p. m.	9 a. m.	5 p. m.
	°F.	°F.	°F.	°F.
April 12.....	102.8	.....	101.2	.....
April 13.....	101.2	104.4	101.2	101.6
April 14.....	104	104.2	101	101.4
April 15.....	103	102.8	101	102
April 16.....	103.2	103	101.4	102
April 17.....	103	103.7	101.4	101.6
April 20.....	102	103.5	101.4	100.8
April 22.....	102.2	104	100.8	102.2
April 23.....	102.6	103.8	101.6	102
April 24.....	102.7	103	101.6	100.8
April 25.....	102.5	103.5	101.4	102

* The continued elevated temperature of No. 160 is due to the advanced stage of pregnancy, perhaps. No. 160 drops a healthy calf May 9. No. 152 calves September 5.

Intravenous inoculation of pigs.—April 11, two pigs, five to six months old, numbers 472 and 473, received each by inoculation into the vein on the inside of the thigh, 5 cc. of a peptone bouillon culture twenty-four hours old. On April 12 and 13 both pigs were quite dull and eating but very little. On April 14 to 16 the pigs were active and appetite returning. On April 17 they had apparently entirely recovered.

ON A PATHOGENIC BACILLUS FROM THE VAGINA OF A MARE AFTER ABORTION.

By THEOBALD SMITH.

The two tubes of inclined agar inoculated by Dr. F. L. Kilborne, as described in his report, were handed to me the day following the inoculation. I may repeat here that these tubes were inoculated directly with a platinum loop rubbed over the mucosa of the vulva. They were inoculated in the morning, the abortion having occurred the evening before. In each tube there had appeared, twenty-four hours after inoculation, about a dozen roundish, grayish-white colonies, several millimeters in diameter. Some of the growth from each tube seems to have run down the inclined surface of the agar as if semi-liquid. Microscopic examination revealed small rods which did not show any motion when stirred up in sterile water and examined in a hanging drop. Both tubes evidently contained but this one species. From a colony in each peptone bouillon, tubes were inoculated and placed in the thermostat. Both were clouded on the following day and contained short motile rods closely resembling in size and motility hog-cholera bacilli. From both cultures gelatine plates were prepared. On the third day colonies appeared on both sets of plates which were all alike. The bacteria composing them were motile and identical with those in the original tubes. From a colony on a gelatine plate a peptone bouillon culture was prepared, and from this two rabbits were inoculated. The source of the culture may be tabulated thus:

March 5, 1891, agar inoculated from vagina of mare.

March 6, peptone bouillon.

March 9, gelatine plates.

March 12, peptone bouillon
(from colony).

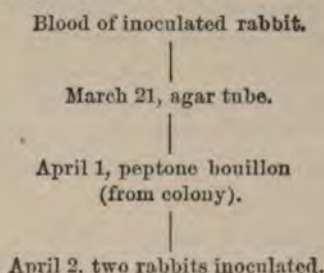
March 14, two rabbits inoculated.

Rabbit No. 1 received into an ear vein 0.3 cc. of the culture liquid.

Rabbit No. 2 received under the skin of the abdomen the same quantity.

The first rabbit appeared ill on the second day; the inoculated ear slightly swollen and turned back on the head. The same condition prevailed on the third day. Seven days after inoculation it was found dead. As the writer was confined to his bed at this time the animal was examined and the cultures prepared by Dr. V. A. Moore. The spleen very much enlarged, dark, friable. The liver sprinkled with minute areas of necrosis as in hog cholera. In pericardial sac blood-stained serum. The left lung cedematous and some serum in left pleural sac. In cover-glass preparations of both spleen and liver stained with alkaline methylene blue are observed groups of short bacilli. In the blood they are not detected. An inclined agar tube inoculated with a loop of blood showed on the following day about ten nearly round, isolated colonies. They are nearly flat, slightly raised disks from $1\frac{1}{2}$ to 2 millimeters in diameter, of a grayish-white color. An agar tube inoculated with a trace of spleen pulp showed on the following day a large number of isolated and confluent, quite small colonies. The condensation water was covered with a very thin, papery membrane. A peptone bouillon tube inoculated from the spleen at the same time shows, as did the examination of the colonies from the agar tubes, the same motile bacillus which had been injected into the rabbit. The second rabbit remained well until the sixteenth day, when it was unable to move its hind limbs. It was chloroformed at once. No internal lesions were detected. At the place of inoculation slight purulent infiltration of the skin, with enlargement of the neighboring kneefold glands. The spinal cord was not examined.

A second pair of rabbits were subsequently inoculated, the source of the culture used being as follows:



Rabbit No. 3 received 0.3 cc. into abdominal cavity.

Rabbit No. 4 received 0.3 cc into an ear vein.

No. 3 did not become ill. Killed on the twelfth day. It showed no trace of local or general infection.

No. 4 died suddenly March 6, four days after inoculation.

The spleen very large, dark and quite firm. A portion of dorsal surface converted into a yellowish necrotic layer. Liver pale. Besides the general parenchymatous changes the tissue was permeated with a network of yellowish necrotic lines. Parenchymatous degeneration of kidneys. Urine turbid; contains very short fragments of granular casts.

Cloudy swelling of myocardium associated with fatty degeneration. Scattered

over ventricular surfaces are yellowish lines parallel to the course of the fibers and about 1 or 2 mm. long. These are made up of necrosed fibers.

Lungs congested and œdematous. Scattered petechiæ over surfaces. One-half of the two small right (cephalic and ventral) lobes hepatized. Hepatized foci in left cephalic lobe.

Blackish, hemorrhagic condition of edge of pyloric valve in duodenum. For several inches below this petechiæ in mucosa. Very many bacteria in preparations from spleen, kidneys, and liver. Few in blood.

From the spleen two gelatine roll cultures prepared. From the blood (right ventricle) agar plates. In all these cultures colonies appeared, to be described more fully below, which were made up of the injected bacteria and these only. At the same time a tube of inclined agar was inoculated with a trace of spleen pulp. On the following day about fifteen colonies of the same bacteria appeared. These inoculations proved the pathogenic character of these bacilli and made it desirable to examine them more carefully.

On gelatine plates or in rolls colonies of these bacilli become distinctly visible to the naked eye about thirty-six to forty-eight hours after sowing. When magnified the deep colonies appear as round, finely granular, brownish disks, which may show later on a more or less distinct peripheral, paler zone. Their size depends on the number of colonies. When about 1 cm. apart they reach a diameter of 0.5 mm. The surface colonies are roundish, slightly convex, whitish, glistening disks with margin slightly wavy or delicately notched. When magnified they show a faintly stippled surface. They become not more than 1 to 1.5 mm. in diameter.

On agar plates the colonies are quite large twenty-four hours after sowing when kept in the thermostat. The deep ones are round or lenticular, opaque with finely knobbed periphery, and 1 mm. in diameter. The surface colonies are flattish, barely translucent, grayish-white disks. When magnified, finely granular in appearance. They may attain a diameter of 4 to 8 mm. when one to two centimeters apart.

Occasionally the deep colonies may become nearly 2 mm. in diameter and the surface colonies now and then spread out so as to attain a diameter of 1 to 2 cm. They then have a smooth, shining, mucus-like appearance, as if the growth had flowed over the surface. In some gas bubbles appear, and occasionally some spread out between the agar layer and the glass beneath.

In tubes of inclined agar, the growth of the isolated colonies is the same as that described for the plates. When confluent a grayish smooth growth is the result. The condensation water becomes turbid.

In tubes of gelatine, the track of the wire appears after two or three days as a thin yellowish-white line, which increases but little in thickness with time. On the surface there is very little growth beyond the point of inoculation.

On the cut surface of boiled potatoes in plugged tubes well supplied with water in the bottom, growth takes place. The potato becomes

covered with a straw-colored growth, the abundance of which depends upon the state of the surface as regards moisture or dryness as well as on the nature of the potato.

In peptone bouillon kept in the thermostat there is at first simple cloudiness within twenty-four hours of inoculation. After some days the liquid becomes more turbid, and a thin cohesive pellicle forms on the surface when the culture tube remains undisturbed.

In milk at 37° C., no change takes place which is visible to the naked eye, even after several weeks' sojourn in the thermostat. Subsequent boiling gives a slightly brownish, more translucent tint to the milk.

The bacilli have the same power as the hog-cholera bacilli of causing fermentation in peptone bouillon to which some glucose has been added. Thus, in bouillon containing 2 per cent glucose, 48 per cent of the volume of the closed branch of the fermentation tube had been occupied by gas in three days. Of this 34 per cent was absorbed by potassium hydrate as CO₂; the rest exploded with air (probably hydrogen). In a recent test with somewhat more alkaline glucose bouillon I obtained the following result:

Fermentation tube inoculated December 30, 1892.

December 31, 10 per cent of closed branch occupied by gas.

January 2, 58 per cent of closed branch occupied by gas.

January 4, 58 per cent of closed branch occupied by gas.

In the temperature of the room the gas occupied only 56 per cent of the closed branch. Of this 37 per cent was absorbed by caustic potash; the rest exploded with air. The culture liquid was markedly acid and free from odor. Gas is not set free in saccharose and lactose bouillon.

In reinoculating this bacillus from time to time into fresh tubes of agar the surface growth assumed a more and more pronounced membranous appearance. The agar was covered with a thin, brittle, somewhat wrinkled layer, which extended down over the condensation water. The same change was observed in bouillon in which a thin papery membrane became a prominent feature of later cultures. This may be replaced by other membranes when shaken to the bottom.

The bacillus under consideration is a short bacillus with rounded ends, which stains well in alkaline methylene blue. It is actively motile in bouillon cultures. It moves to and fro in a straight or curved line, frequently twirling about its own middle point as an axis at the same time. When traces of growth from colonies on agar or gelatine are suspended in water or bouillon, this property of motility may escape attention, since only a few move under these conditions, and in some preparations no motile forms were observed.

The presence of this bacillus exclusively, so far as the agar cultures indicated, in the vagina of a mare which had just aborted, was of considerable moment, and it became necessary to determine—

(1) May injections of cultures of this bacillus produce abortion in healthy pregnant mares?

(2) Is this bacillus present in the genital passages of healthy pregnant and non-pregnant mares?

The first problem was undertaken by Dr. Kilborne, and his notes will be found in the preceding article. They show that an injection of culture fluid into the vagina of one mare and two cows in a state of pregnancy was followed by a discharge, but abortion did not take place.

The second problem was taken up by Dr. V. A. Moore. He failed to find in cultures from one pregnant and four not pregnant mares the pathogenic bacillus just described, as the following brief summary of his observations demonstrates:

"A bacteriological examination was made of the vaginal secretions from five healthy mares. Some of them were on a farm adjacent to the experiment station and some from the stables of a horse car company. One of the mares was pregnant. The method employed was the inoculation of agar tubes with mucus taken directly from the walls of the vagina by means of a sterilized platinum loop. From the colonies of bacteria which developed in these tubes subcultures were made, and from all impure original cultures agar or gelatine plates were made. From mares Nos. 4 and 5 the examination was repeated. The inoculations upon agar directly from the animals were made by Dr. F. L. Kilborne.

The number of cultures that were made and the bacteria that were obtained from the different animals are given in the subjoined table:

Mare No.	Number of cultures from vaginal secretions.	Date of cultures.	Number of tubes that remained clear.	Number of species.	Remarks.
	<i>Agar.</i>	1891.			
1	2	April 7	2	.....	
2	1	do		5	2 bacilli, 2 micrococci, 1 streptococcus.
3	2	April 20		2	2 streptococci.
4	2	May 5	1	1	1 streptococcus.
	2	June 10	2	.....	
5	2	May 5		2	1 micrococcus, 1 streptococcus.
	2	June 10	1	2	1 micrococcus, 1 streptococcus.

It should be stated that the cultures from mare No. 3, and the first cultures from No. 5, were pure. The streptococcus from the second set of cultures from No. 5 was not distinguishable from one of the streptococci from mare No. 3. The large number of bacteria from No. 2 and the comparatively small number obtained from the other animals is worthy of note. It will also be observed that streptococci were universally present in the cultures. In all, eleven apparently different species of bacteria were isolated. They were classified as follows: Two non-motile bacilli, four micrococci, and five streptococci. The streptococci were very delicate, and the differences that were found to exist between them were very slight. The micrococci were more saprophytic in their biological characters, and were readily differentiated. One of bacilli the was club-shaped, and resembled morphologically, and in its

cultural characters, the pseudo-diphtheria bacillus. The other bacillus was slender and usually united in chains. It was aerobic and did not ferment glucose."

The results thus far obtained, while they do not demonstrate the causal relation between this pathogenic bacillus and the abortion, nevertheless do not disprove such relation. The negative outcome of the injection experiments should not be rated too high in this connection, for there may be other as yet unknown factors necessary in order that the infectious agent may bring about abortion. It is true that we know nothing as yet concerning the pathological processes involved in epizootic abortion, and it would be premature to claim that some living organism like a specific bacterium is responsible for it. There may be other causes at work of which we have no information. Yet, from the standpoint of to-day, the assumption of living organisms, such as bacteria, explains best the occurrence as related above, and the actual presence of a pathogenic bacillus in the vagina of a mare after abortion is a fact worthy of more attention than we have been able to give it thus far.

Another fact of interest in connection with this pathogenic bacillus is its close resemblance to the hog-cholera bacillus. As I shall show by illustrations in a future article, the specific bacillus obtained directly from outbreaks of hog cholera varies slightly in its biological and morphological characters, and if the bacillus in question had been sent to me as having come from swine I should not have hesitated to regard it as a hog-cholera bacillus of rather feeble virulence, and possessing some slight differential characters from the virulent form. In other words, the differences between this form and the virulent hog-cholera bacillus are no greater than between the hog-cholera bacilli of widely varying pathogenic power which I have thus far investigated. This fact does not of course prove it to be identical with *Bacillus cholerae suis*, but the presumption is strongly in favor of a close relationship. The points of resemblance include form, motility, growth on the various culture media, including the fermentation tube, staining reactions, and pathogenic action. The only points of difference are feebler pathogenic action and a tendency to a membranous growth on agar, which tendency, however, is not pronounced.

Granted the close relationship of this bacillus with the bacillus of hog cholera, it is not safe to infer that abortion in mares stands in a causal relation to hog cholera or the reverse, and yet such relation is by no means disproved by the foregoing investigations. All that we may safely affirm is that there is evidently a wide distribution of bacteria closely related to the hog-cholera bacillus, including such bacteria as *B. enteriditis* Gärtner, *B. typhi murium* Löffler, and the bacillus under discussion. This possible relationship brings up the important question whether certain specific infectious diseases of any given species of domesticated animals may appear also in other species, but un-

der a different form, and therefore only identifiable by a study of the bacteria or other microorganisms which produce them. May we, in other words, have diseases among domesticated animals known under different names and yet due to the same cause? Pending the solution of such problems by a thorough investigation of all communicable diseases among domesticated species and species of wild animals coming in contact with them, we would urge owners and breeders of animals not to take it for granted that diseases, even among different species of animals, are necessarily different until such has been demonstrated to be the case by investigation. In other words, the indiscriminate mingling of sick and healthy animals may be really more dangerous than we are in the habit of regarding it.

The results of this investigation may be briefly summarized as follows:

1. The discovery of a pathogenic bacillus in the vagina of a mare soon after abortion.
2. The very close relationship between this bacillus and the hog-cholera bacillus.
3. The production of a slight discharge by the injection of cultures into the vagina of a pregnant mare and two pregnant cows.
4. The absence of this bacillus from the genital passages of one pregnant and four non-pregnant mares.

SOME EXPERIMENTAL OBSERVATIONS ON THE PRESENCE OF TUBERCLE BACILLI IN THE MILK OF TUBERCULOUS COWS WHEN THE UDDER IS NOT VISIBLY DISEASED.

By THEOBALD SMITH and E. C. SCHROEDER.

The possible dangers to health arising from the consumption of meat and milk from tuberculous cattle were discussed by one of us in a former report,* and the state of the subject summarized from the results of experiments made by various observers up to that time. Since then a small number of milch cows which were affected with this disease have come under observation in the District of Columbia. It was deemed advisable to take up this subject and determine if possible the extent of milk infection and its relation to the general condition of the animal. Only a small number of cases have been experimented on, but the facts are published now, inasmuch as they have accumulated very slowly and are not likely to be collected any more rapidly in the future.

The tuberculous animals were taken to the Veterinary Experiment Station where they were in charge of F. L. Kilborne, B. V. S., to whom we are indebted for some of the clinical notes. The two cases reported first have been already briefly referred to in a former report.† To determine the presence or absence of tubercle bacilli a certain quantity of milk, in the later cases centrifugalized, was injected directly into the abdomen of guinea-pigs. These were kept under observation a certain length of time before being killed for examination.

No. 155, Jersey cow, seven years old, from a large herd in the District of Columbia. Tuberculosis diagnosed, and the animal transferred to the Experiment Station February 28, 1891.

There was at this time some emaciation, which became more marked in the following months. The animal lived until June 24, on which day she was found lying down in an insensible condition, and was dispatched by a blow on the head. At the autopsy advanced caseous masses were found in both lungs as well as in the bronchial and mediastinal glands, which were enormously enlarged.

* Report of the Secretary of Agriculture for 1889, p. 104.

† Report of the Secretary of Agriculture for 1891, p. 135.

Guinea-pigs were inoculated as follows:

No. of animal.	Weight.	Quantity of milk injected.	Date of injection.	When killed.	Weight when killed.	Remarks.
	<i>Ounces.</i>	<i>O O.</i>	1891.	1891.	<i>Ounces.</i>	
1.....	14.5	7	Mar. 18	May 12	20	No tuberculosis.
2 (male).....	13	7	...do...	July 29	33	Do.
5 (female)....	11	5	Apr. 4	...do...	20	No tuberculosis; animal nursing one young.
6 (female)....	12.5	5	...do...	...do...	25	No tuberculosis.
9 (female)....	.....	7	June 22	Oct. 10	27	Tuberculosis.
10.....	24	7	...do...	...do...	30	No tuberculosis.

This table shows the absence of tuberculosis in all but one case, which had been inoculated with milk (together with one other) only two days before the cow was in a dying condition, and when the secretion had nearly ceased.

The tuberculous lesions in this guinea-pig are of interest. The anterior mediastinal glands at the root of the thorax were quite large and contained calcareous foci. There were a small number of sub-pleural tubercles. The spleen, though not much enlarged, contained bunches of tubercles projecting slightly above the surface, and giving the organ a nodular appearance. A few necrotic foci were found in the liver. The guinea-pig was quite large and fat when killed, and no one would have suspected tubercular infection.

These inoculations show that even though the cow was emaciated the milk did not contain tubercle bacilli until shortly before death, and even then only one out of two inoculated guinea-pigs became infected.

No. 156, Jersey cow 8 or 9 years old, from the same herd as No. 155. Tuberculosis diagnosed February 28, 1891, and the cow transferred to the experiment station on this day. Emaciation had already set in and continued, so that at the time of her death, June 5, 1891, she was a mere skeleton.

There were extensive tuberculous growths on the omentum and in the peritoneum covering the paunch, the diaphragm, the abdominal walls, the spleen, kidneys and liver. The mesenteric, portal, and renal glands were transformed more or less into caseous masses. Of the abdominal organs there were tuberculous foci in the liver and the kidneys. Those in the kidneys were few in number and calcified. The Fallopian tubes and the lining membrane of the uterus contained very extensive cheesy deposits. In the thorax, the lungs were very extensively involved in tuberculosis, similarly all the lymph glands and the costal and pulmonary pleura. There were large deposits on the epicardium. The infection of the glands in the muscular tissue was not specially searched for. It should be mentioned, however, that there were no enlarged glands visible in any portion of the body, and that the axillary glands were normal. The udder was free from all changes visible to the naked eye.

Only four guinea-pigs were inoculated with the milk of this cow.

No. of pig.	Weight.	Date of injection.	Quantity injected.	When killed.	Weight when killed.	Remarks.
	<i>Ounces.</i>		<i>CC.</i>		<i>Ounces.</i>	
3 (female)	12.25	Mar. 18	7	May 12	14	No tuberculosis.
4 (female)	13.25	... do....	7	July 29	*16	Do.
7 (male)	9.50	Apr. 4	5	July 29	23	Do.
8 (male)	12.25	... do....	5	... do....	27	Do.

*Nursing three young.

The milk from these cows was used to feed two pigs as long as it lasted. This was done by Dr. Kilborne, who has furnished the following notes concerning the feeding :

Pig No. 489.—Female, 2 months old on April 16, 1891; weighed 14 pounds.

Pig No. 490.—Female, 2 months old on April 16, 1891; weighed 16½ pounds.

On April 16 the feeding was begun. Each pig received daily about 1 gallon of milk in two meals until May, when the quantity began to decrease. On June 5, No. 156 died and No. 155 furnished about 1 quart daily until June 20, when the milk gave out.

Both pigs were killed July 29, 1891. At this time No. 489 weighed 63 pounds, and No. 490 78 pounds. Both were in excellent condition and the organs free from disease.

No. 233, Jersey cow, 7 years old. Tuberculosis diagnosed, and the animal sent to the Experiment Station August 31, 1892. At this time she was quite thin and coughed more or less. Enlargement of subcutaneous lymphatics not discoverable.

Up to October 5 she was milked once a day, and on this day she gave only about a pint. She was failing rapidly, and on October 11 she was found dead.

At the autopsy tuberculous processes were observed in the following organs and localities :

In the cortex of one lymph gland behind udder a few quite small tubercles with yellowish center. The omentum over paunch studded with a large number of confluent tubercles; similarly the abdominal surface of the diaphragm. The capsule of liver and spleen was studded with tubercles, but the parenchyma of both organs was free. The mesenteric and portal glands extensively necrosed. Through the parenchyma of kidneys were disseminated cheesy tubercles from 1 to 2 inches apart, and about one-eighth inch in diameter.

Extensive tuberculous disease of the Fallopian tubes and ovaries, as well as of the mucous membrane of the uterine horns.

In the thorax the anterior and posterior mediastinal glands, as well as the bronchial glands, are greatly enlarged and converted in part into caseous masses. Through the parenchyma of both lungs are disseminated caseous foci of various sizes, while the small lobes of the right lung (cephalic and ventral lobes) are completely transformed into caseous masses. The pleura over these lobes is thickly studded with tubercles.

The milk was tested a short time before the death of the animal, and although the udder contained, so far as the naked eye could tell, no foci of disease, the secretion contained tubercle bacilli, as the following table demonstrates:

No. of guinea-pig.	Weight.	Date of injection.	Quantity of milk.	When killed.	Weight when killed.	Remarks.
	<i>Pounds.</i>	1892.	<i>CC.</i>	1892.	<i>Pounds.</i>	
302	1.25	Oct. 4.	5	Dec. 24.	1.343	No tuberculosis.
303	1.18	do	5	do	1.343	Do.
304	1.18	do	5	do	1.25	Tuberculosis.
305	1.5	do	5	do	1.314	Do.
306	0.95	do	5	do	1.047	Do.
309	1.37	Oct. 8.	5	do	1.25	Do.
310	1.5	do	5	do	1.156	Do.
311	1.18	do	5	do	0.953	Do.
312	1.5	do	5	do	1.375	Do.
313	1.43	do	5	do	1.265	Do.

NOTE.—Nos. 302 to 306, inclusive, received milk from left forequarter only. Only about 50 cc. could be drawn at the time. Nos. 309 to 313, inclusive, received milk from the other quarters mixed.

Of the first five cases three were found tuberculous. Of the second lot of five all were tuberculous. The first set had been inoculated with milk drawn from the udder seven days before death; the second set with milk drawn only three days before death. There was, therefore, a distinct increase in the number of bacilli in the milk as death approached. That the animal was perhaps going through the earliest stages of an acute generalized miliary tuberculosis affecting the udder as well as the other organs of the body was suggested in the microscopic examination of a fresh section of liver tissue, in which a group of three giant cells came clearly into view. Sections of hardened tissue have not been examined.

As to the character of the tuberculosis affecting the guinea-pigs the following general remarks will suffice:

1. Marked enlargement of the lymph glands of abdomen, especially the one behind (or dorsad of) the stomach, and of those at root of thorax (anterior mediastinal).

2. Puriform, semi-fluid condition of the contents of these glands excepting in one case in which they were still firm.

3. In two cases the subcutaneous glands were affected.

4. Marked nodular condition of the spleen owing to agglomerations of tubercles within its substance.

5. Lines of retraction of the convex surface of the liver with very few distinctly tuberculous lesions.

6. Tubercles of the omentum in several cases.

No. 234, Jersey cow from the same herd as No. 233. Sent to the Experiment Station August 31, 1892, with the latter. Tuberculosis suspected from physical signs. Positive reaction with tuberculin at two different times. She was killed February 6, 1893, in a condition of marked emaciation. Of the autopsy notes, the following may be quoted:

Udder, together with lymph glands, normal.

In the thorax, the caudal half of both principal lobes firm, nodular to the touch.

On section tuberculous foci of various dimensions from miliary tubercles up to caseous foci fully three-fourths of an inch in diameter. The bronchi contain an abundance of muco-pus. Scattered masses of tubercles on the pleura of the diseased areas and on corresponding costal pleura. Bronchial and mediastinal glands very large with caseous contents.

In abdomen the mesenteric glands are very large and transformed into caseous masses which contain calcareous particles. In the capsule of the liver three cheesy nodules as large as peas. Parenchyma of this organ as well as of spleen and kidney free from tuberculosis, although the gland at the hilus of the latter is enlarged and partly caseous.

The milk from this cow was centrifugalized before injection into guinea-pigs. The small Litten hand-centrifugal machine was used for this purpose. According to Scheurlen* bacteria do not behave alike under the influence of this process. Anthrax bacilli and their spores, the bacilli of typhoid fever and Asiatic cholera, gather in the cream, while tubercle bacilli are thrown down. In the same way tubercle bacilli tend to settle when milk is allowed to stand for some time in the refrigerator. Basing our procedure on these determinations we retained the milk in the bottom of the tubes after centrifugalizing and rejected the rest. The glass tubes which were to hold the milk during centrifugalizing were sterilized dry beforehand. The milk drawn as heretofore directly into cotton-plugged, sterilized 6-ounce wide-mouthed bottles, was distributed into the four tubes of the centrifugal machine and revolved for forty-five minutes at a rate of 1200 revolutions per minute. The milk and cream at the surface was then carefully withdrawn with a sterile pipette and about 0.5 cc. in the bottom retained.

The following table gives in brief the experimental inoculations with the milk from No. 234:

No. of guinea-pig.	Weight.	Date of injection.	Quantity injected.	Centrifugalized from.	Guinea-pig killed.	Weight when killed.	Remarks.
	<i>Pounds.</i>		<i>CC.</i>	<i>CC.</i>	<i>1893.</i>	<i>Pounds.</i>	
359.....		Dec. 23, 1892	1	40	Mar. 25	.....	No tuberculosis.
355.....	1.06	Dec. 24, 1892	6 }	40	Mar. 10	1.11	Do.
362.....	1.09	Dec. 28, 1892	4.5 }	40	do	1.06	Do.
360.....	1	Jan. 10, 1893	5.5 }	80	April 13	1.5	Do.
361.....	1.5	do	6 }	80	do	1.28	Do.
263.....	1.125	Jan. 11, 1893	5.5 }	100	do	1.28	Do.
264.....		do	5.5 }	100	do	.....	Found dead of pneumonia 5 days after inoculation.
272.....	1.125	Jan. 28, 1893	6 }	60	do	1.25	No tuberculosis.
373.....	1	do	6 }	60	do	0.93	Do.

In almost every case the milk was allowed to stand over night in the ice chest, and only the lower strata centrifugalized. In this way both sedimentation and centrifugalizing came into play. Granted that the latter process acts as determined by Scheurlen, the milk of this cow, even in the far advanced stage of tuberculosis, was free from tubercle

* Ueber die Wirkung des Centrifugirens auf Bakteriensuspensionen besonders auf die Beurtheilung der Bakterien in der Milch. Arbeiten aus dem Kaiserl. Gesundheitsamte, VII, 1891, 269.

bacilli. Cover-glass preparations of the sediment, prepared January 28, were carefully examined for tubercle bacilli, but only a small number of multinuclear leucocytes were detected.

Cow No. 303.—The milk from this animal was tested but once. On December 8, 1892, 60 cc. was centrifugalized for thirty minutes. In a little of the sediment stained, multinuclear leucocytes were detected, but no tubercle bacilli; 6 cc. of the milk in the bottom of the tubes was injected into the abdominal cavity of guinea-pig No. 356. It was killed with chloroform March 25, 1893, and found healthy.

The cow was killed March 18, 1893, a little more than three months after the milk was tested. Tuberculous foci partly caseous, partly calcareous, were found in the lymphatic glands behind the udder; about half a dozen tuberculous foci in the lungs, one as large as a hen's egg. The bronchial, mediastinal, mesenteric and portal lymph glands contained tuberculous masses.

Cow No. 314.—The milk of this animal was tested at the same time. The guinea-pig inoculated with 6 cc. of centrifugalized milk was killed with the preceding, three and one-half months after the inoculation, and a little grayish, pneumonic infiltration of one lung discovered. Tuberculosis not detected.

The cow was killed March 18, 1893. The udder and corresponding lymph glands were free from disease. Tuberculosis of the lungs was present in the form of several foci, one 4 by 2½ inches in size. The bronchial and mediastinal glands were considerably involved; the portal and mesenteric glands only slightly so.

The facts thus far obtained may be most conveniently put into the form of a table in which the period of injection of the milk is outlined by the last negative and first positive results:

No. of cow.	Tubercle bacilli present.	Tubercle bacilli absent.	Condition at autopsy of—		Condition of animal at time of death.
			Udder.	Udder glands.	
155	2 days before death.	2½ months before death.	Normal	(f)	Tuberculosis very extensive.
156	.....	2 months before death.	...do.....	(f)	Do.
223	6 days before death.	.....	...do.....	Slight infection ...	Do.
234	.....	9 days before death.	...do.....	Normal	Do.
303	.....	3½ months before killed.	...do.....	Tuberculous.....	Tuberculosis moderate.
314	.....	...do.....	...do.....	Normal	Do.

These determinations show, as was suggested in the article referred to above, that if a rigid inspection of all dairy herds be enforced so that all animals showing any affection whatever of the udder, or any emaciation, could be at once removed from the herd and the milk condemned,* perhaps most of the infected milk would be thereby excluded. This inspection does not settle the serious question of bovine tuberculosis in

*This should be done even if the reaction with tuberculin proves negative.

its relation to human health. It would, however, be a great stride toward the settlement of this question, pending a more accurate determination of the extent of the disease. The use of tuberculin and the more careful examination of the organs at the abattoirs in Europe is revealing a much higher percentage of tuberculous cattle than had been heretofore even suspected, and we shall soon be prepared to publish additional interesting facts and deductions bearing on this important matter.

ADDITIONAL OBSERVATIONS ON TEXAS CATTLE FEVER.

By THEOBALD SMITH, F. L. KILBORNE, and E. C. SCHROEDER.

ON THE INDEFINITE PERSISTENCE OF THE TEXAS-FEVER PARASITE IN THE BLOOD OF SOUTHERN CATTLE.

Since the preparation of Bulletin No. 1 of the Bureau of Animal Industry on Texas cattle fever, several additional facts have been discovered concerning the peculiar nature of this disease which we deem of sufficient importance to place on record.

In the bulletin referred to (p. 119) it was shown that the blood of Southern (North Carolina) cattle contained the micro-parasite of the disease some time after such cattle had left the permanently infected territory, and after they had been rid of cattle ticks. In the final experiment recorded, the blood of a Southern cow (No. 214) was still capable of producing disease in natives when injected into a jugular vein seventy-four days after the animal had left the permanently infected territory, and about fifty days after the last ticks had been removed.

In continuation of the same investigations another native (No. 211) was inoculated with the blood of the same Southern cow (No. 214) on October 13, 1892, or one hundred and eight days after the latter had left North Carolina pastures. The native was a tuberculous cow in fairly good condition. An enormously enlarged lymphatic gland was situated behind the angle of the lower jaw. The inoculation was made as in previous cases, the blood being drawn from the jugular of No. 214 with a large hypodermic syringe and injected directly into the jugular vein of No. 211. The following table and notes give the subsequent history of this case:

No. 211.

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Remarks.
		In fresh preparations.	Dried and stained.	
Oct. 13, 1892	5,678,500 (white 7,142).	5 percent bright bodies; size variable; some motile.	None	Jersey heifer, 2 years old, received April 20, 1892, affected with tuberculosis; has a large gland behind lower jaw on left side; expiration and inspiration accompanied by a grunting sound; expiration much prolonged. Receives into left jugular 28 cc. (2 syringefuls) of fresh blood drawn directly from cow No. 214.

No. 211.—Continued.

Dates.	Number of red corpuscles.	Parasites in red corpuscles.		Remarks.
		In fresh preparations.	Dried and stained.	
Oct. 18, 1892	5,250,000 (white 13,750).	15 to 20 percent bright bodies up to $\frac{1}{2}\mu$ in diameter; 4 or 5 in some corpuscles.	None.....	
Oct. 22, 1892	4,304,875 (white 4,875).	About 3 percent large parasites; some change their outline.	Both paired and single parasites.	
Oct. 24, 1892	2,677,000 (white 5,555).	Many bright bodies; 1 to 2 percent large parasites; many in pairs and pyriform.	Same as in fresh preparations.	Appetite partly lost.
Oct. 25, 1892	.....	5 to 10 percent bright bodies; large parasites very scarce.	None.....	Refuses all food; lies down most of the time; losing flesh rapidly.
Oct. 27, 1892	.....	.....	.....	Found dead this morning; no hæmoglobinuria observed during the fever, although the animal was carefully watched.

The temperature of this animal began to rise October 14, reaching its highest point (105.8) October 18.

AUTOPSY NOTES.

Animal in good condition as regards fat. Weighs about 550 pounds. Hemorrhagic discoloration of the left superficial jugular vein extending from the place of injection to the root of the neck and toward the head. On the left side, resting against the larynx, a fluctuating gland fully 4 inches in diameter. It is readily dissected out, and when incised the thickened capsule is found to inclose a turbid fluid holding caseous masses in suspension. Near this gland is a smaller one with contents completely caseous.

Heart.—Usual ecchymosis under epicardium and under endocardium of left ventricle. Both ventricles contain dark coagula of moderate size. Parenchymatous changes of heart muscle very slight. Lungs not collapsed. Subpleural emphysema over portions of smaller anterior lobes. Red hepatization of a portion of the right ventral, of a contiguous portion of the right principal, and of the entire azygos lobe. The two first-mentioned lobes are interspersed with small necrotic foci. The whole emits an offensive odor. The portion of diaphragm nearest the hepatized azygos lobe is sprinkled with hemorrhages. The lung contains some tuberculous foci as follows: A soft cheesy mass, 1 inch in diameter, in the left cephalic, a similar one in the right principal lobe, and a smaller one in the hepatized region of the right ventral lobe. Bronchi of hepatized regions intensely dark red; occasionally clumps of yellowish masses encountered. The pneumonia is probably due to a recent discharge of a caseous mass into a bronchus, resulting in aspiration pneumonia of a septic character.

Spleen.—Weighs $5\frac{1}{2}$ pounds, 25 inches long, 8 wide, and $1\frac{1}{2}$ thick. More or less extravasation of blood from vessels of capsule. Usual markings of pulp effaced by the great engorgement with blood corpuscles.

Liver.—Weighs $14\frac{1}{2}$ pounds without gall bladder. Color paler than normal. The surface sprinkled with closely set irregular grayish spots about $\frac{1}{2}$ mm. in diameter. On section the liver presents a decidedly yellowish appearance. Much thick blood flows from hepatic vessels. The grayish points not visible on the cut surface. In fresh sections occasional areas of bile stasis noticed and much fatty degeneration of the parenchyma. Intracellular pigment abundant.

Bile.—(8 ounces) is very highly charged with flakes, so that it scarcely flows.

Kidneys.—Much paler than normal. On the surface seen all number of grayish spots corresponding on section to grayish cylindrical lines passing through the cortex and indicative of fatty changes. Similar radial lines on pyramidal portion corresponding to tubules filled with fat globules. Much pigment in the form of granules up to 0.5μ in diameter in the epithelium of cortex and medulla. Papillae more or less reddened and the inclosing calices are ecchymosed.

Urine.—Pale yellow; contains a trace of albumen.

Digestive tract.—Slight bluish-pink discoloration of mucosa of fourth stomach. Mucosa of small intestines pale and covered with a pasty, bile-stained layer of desquamated epithelium.

Uterus.—Contains a fetus 10 inches long.

The number of infected corpuscles was quite small at this stage of the disease. In the capillary blood from the heart none were seen. In the liver and spleen only a few were detected. In kidney preparations from 1 to 2 per cent were present. They are large, roundish, mainly single. A small number of tinted macrocytes are present in the various organs.

The following case is of unusual interest, for it demonstrates that the Texas fever parasite may remain an indefinite length of time in the blood of insusceptible animals.

No. 113, a cow brought from North Carolina in September of 1889, and at that time $3\frac{1}{2}$ years old, has been kept on the Station since that time. She has not been exposed in fields infected with ticks or Southern cattle or sick native cattle. She has, in other words, not come in contact with the Texas fever infection in any way.

On October 29, 1892, a native cow, No. 235, which had been on the Station during the past two years, was inoculated with the blood of No. 113 in the way indicated in the preceding case. A syringe of blood (14 cc.) was withdrawn from a jugular vein of No. 113 and injected at once into a jugular of No. 235. This was repeated, hence the latter animal received 28 cc. in order that the experiment might be a precise parallel to similar ones made earlier in the season.* The following tabulated record demonstrates the presence of Texas fever:

No. 235.

Date.	Number of red corpuscles.	Parasites in red corpuscles.		Condition of red corpuscles.	
		In fresh preparations.	Dried and stained.	In fresh preparations.	Dried and stained.
Oct. 29, 1892	6,375,000 (white 10,000).	Some bright bodies.	None.....	Normal.....	Slight variation in size.
Nov. 9, 1892	5,050,000 (white 6,250).	Negative.....	Several irregular and one pair pyriform parasites.	do.....	Do.
Nov. 12, 1892	3,815,555 (white 7,700).	A few bright bodies.	Several parasites of irregular outline.	do.....	Normal.
Nov. 14, 1892	4,257,500 (white 7,500).	do.....	None.....	do.....	Do.
Nov. 19, 1892	5,575,000 (white 10,000).	do.....	do.....	5 to 10 percent macrocytes up to 8μ in diameter.	Same as in fresh preparations.
Nov. 30, 1892	4,700,000 (white 18,750).	(Preparation poor.)	Negative.....	A few macrocytes.	A few macrocytes.

NOTE.—The temperature in this case was high from November 6 to November 13.

* Bulletin No. 1, p. 119.

As a parallel to the preceding inoculation the following may be cited here, although it does not bear directly on the subject under discussion:

On August 27, 1892, defibrinated blood from a case of Texas fever* collected with all precautions necessary in bacteriological work, was drawn up into sterile pipettes and some placed at 36° C., others in a dark receptacle at the ordinary temperature. These pipettes remained undisturbed until November 3, when the blood was withdrawn from all and mixed together, making about 7 cc. It was free from bacteria. This blood was injected into a jugular vein of No. 236. The record below shows that no disease was produced. The blood at the time it was drawn and after a few days' standing in a cool place produced Texas fever in four cases inoculated therewith.†

No. 236.—Cow, 5 years old, received October 29, 1892, from Maryland.

Dates.	Number of red corpuscles.	Parasites in red corpuscles.	
		In fresh preparations.	Dried and stained.
Oct. 29, 1892	6,609,370 (white 10,937).....	Some bright bodies.....	None.
Nov. 9, 1892	6,737,500 (white 13,759).....	do.....	Do.
Nov. 14, 1892	6,093,000 (white 6,066).....	do.....	Do.
Nov. 19, 1892	6,475,000 (white 7,500).....	do.....	Do.

NOTE.—The temperature of this case at no time rose above 102.6° F.

The following severe case of Texas fever, followed by relapse, was produced in midwinter by inoculation with blood from a North Carolina cow:

No. 237, a native cow, 5 years old, from Prince George County, Md., was inoculated January 12, 1893. Twenty-eight cc. of blood, drawn with a hypodermic syringe from a jugular vein of North Carolina cow No. 214, was injected directly into a jugular vein of this cow. The fever appeared in five days, and the destruction of the red blood corpuscles was well under way on the seventh day after inoculation, as the table below shows:

No. 237.

Dates.	Number of red corpuscles.	Parasites in red corpuscles.		Remarks.
		In fresh preparations.	Dried and stained.	
Jan. 10, 1893	5,962,500 (white 10,000).	2 to 3 per cent bright bodies.	None	Injection made to-day.
Jan. 12, 1893	4,287,500 (white 10,000).	A few bright bodies; 1 per cent amoeboid and paired parasites.	One-half per cent large, single and paired parasites.	
Jan. 19, 1893	3,561,000 (white 42,465).	Parasites very scarce.	Several large parasites in each preparation.	Appetite failing.
Jan. 21, 1893	2,314,000 (white 4,271).	do	Very few parasites ...	
Jan. 25, 1893				January 26. Gave birth to a calf last night; has lost considerable flesh and is very weak.

* Bulletin No. 1, p. 81.

† Loc. cit.

No. 237.—Continued.

Dates.	Number of red corpuscles.	Parasites in red corpuscles.		Remarks.
		In fresh preparations.	Dried and stained.	
Feb. 17, 1893	1,851,300 (white 4,054)	None	Some peripheral cocci.	Relapse beginning.
Mar. 1, 1893	1,033,000 (white 1,515).	Some pale peripheral bodies.	5 per cent peripheral cocci.	
Mar. 20, 1893	1,246,000 (white 6,350).	{ Some bright bodies . Some pale peripheral bodies.	{ Some peripheral cocci.	
Mar. 31, 1893	2,170,000 (white 6,154).	A few bright bodies .	Very few peripheral cocci.	

NOTE.—The temperature in this case remained high (103.5–105.5) almost continuously from January 17 to January 25.

ON THE PERSISTENCE OF THE TEXAS-FEVER PARASITE IN THE BLOOD OF INOCULATED NATIVE CATTLE.

That the Texas-fever parasite might persist in the blood of susceptible cattle long after recovery from the disease did not suggest itself until this interesting fact was accidentally discovered.

In 1891 several animals which had been inoculated with blood from a case of Texas fever passed through a severe attack of this disease.* Two of these were reëxposed the following summer.

Just before the exposure on the infected pasture the customary blood examination was made, and it was found that in one of these animals the Texas-fever micro-parasite was present, though in very small numbers. The peculiar pyriform bodies in pairs within the red corpuscles left no doubt as to their nature. Inasmuch as this animal had not been exposed to the infection since the inoculation, the only conclusion which could be reached was that the micro-parasite had persisted in the blood since last fall. This persistence, astonishing in itself at the time, is now quite in harmony with the long life of the species in the blood of Southern cattle.

Another fact of interest is the insusceptibility on the second exposure of the animal in which the micro-parasite was found. The other animal, whose blood on microscopic examination no longer revealed the micro-parasite, was not insusceptible, for it passed through a well-marked but mild attack.

ON PREVENTIVE INOCULATION.

The foregoing observations furnish an important basis for a rational method of protective inoculation with reference to Northern cattle about to enter the Southern permanently infected territory. We have shown in the foregoing pages and in the bulletin on Texas fever that the blood of Southern cattle contains the micro-parasite of Texas fever an indefinite length of time, and that every intravenous inoculation with such blood has produced the disease in natives. Moreover, the disease induced by a single inoculation of such blood is by no means so

* Bulletin No. 1, pp. 80 and 134; also Nos. 182 and 185 in the appendix.

fatal as the natural disease. In fact, we have recorded but one death in midsummer due to inoculation. A third important consideration is the production of the inoculation disease at all seasons, even in midwinter.

Putting these facts together we are led to the inference that, inasmuch as a well-marked attack of Texas fever will probably protect from a future fatal attack, the first attack might be induced artificially in fall or winter by direct inoculation. In other words, the protective inoculation would be a real attack of the disease. It is not likely that, even in older cattle, such inoculation would result fatally in late fall or winter. Of inoculation with the blood of sick natives we can not make such positive statements, since we have had a considerable percentage of deaths in September from such inoculations.

In the bulletin on Texas fever it was suggested that native cattle might be exposed to a mild form of the disease by scattering ripe, egg-laying ticks on an inclosed pasture upon which the cattle to be exposed are confined. While we have found nothing thus far to invalidate this method, we nevertheless feel that the method of intravenous inoculation can be made more certain by some additional experimenting. It is desirable to determine, also, whether the simple subcutaneous injection of blood from Southern cattle will suffice to induce Texas fever. The subcutaneous injection of defibrinated blood taken from natives during the fever was followed by positive results (in one old cow, by death). The much larger number of micro-parasites in such blood will perhaps account for the very positive results obtained.*

It should be stated that preventive inoculation is of no avail during the prevalence of the disease, owing to the long duration of the disease and the consequent slow acquisition of immunity.

In conclusion, the important facts in this article may be very briefly summarized as follows:

1. The indefinite persistence of the micro-parasite of Texas fever in the blood of Southern cattle after removal from the enzootic territory.
2. The persistence (for nearly a year) of this micro-parasite in the blood of an inoculated native.
3. The production of a severe case of this disease in midwinter by inoculation.
4. The destruction of the micro-parasite in a quantity of defibrinated blood kept sixty-eight days before it was tested by inoculation.
5. The probable development of a simple method of preventive inoculation by the use of blood from Southern cattle.

* Since this was written, subcutaneous inoculation with blood from Southern cattle has been found equally efficacious. The intravenous injection thus becomes unnecessary.

PRELIMINARY NOTES ON A SPOROZOÖN IN THE INTESTINAL VILLI OF CATTLE.

By THEOBALD SMITH.

[Plate I.]

In the summer of 1889, during the examination of cattle which had succumbed to Texas fever, I observed on the mucous membrane of the small intestine in its lower portion minute white bodies of a spherical outline which were just visible to the naked eye. Several observers, even when informed of their presence in a given portion of the mucous membrane, passed them by at first until they were directly pointed out. They may, therefore, pass unnoticed, unless the scrutiny of the mucosa is sharp. When the membrane is stroked with the back of the scalpel it will be noticed that these bodies change their place slightly without becoming detached, indicating that they are located within the villi near their free end. This supposition is confirmed by carefully removing a number of villi, where such a body is found, with small forceps, and examining them under a low power. It will then be seen that an opaque round or slightly oval body is situated within one of them directly under the epithelial layer. The removal is accomplished best by clasping at their roots the villi in the immediate vicinity of such a body with delicate forceps and gently pulling upward. The parasite comes away intact, and is easily teased out of the adherent cell mass without rupture of the cyst. These bodies vary considerably in size, and are either spherical or ovoid. Of a number of measurements of bodies of the larger varieties the following may be quoted:

- (1) 0.416^{mm} long, 0.364^{mm} broad.
- (2) 0.312^{mm} long, 0.208^{mm} broad.
- (3) 0.312^{mm} long, 0.312^{mm} broad.
- (4) 0.364^{mm} long, 0.312^{mm} broad.

It is probable that the weight of the cover glass may have distorted somewhat the true form, and this may account for the varied relation of length to width in these measurements. We may roughly speak of the larger bodies as from 0.3 to 0.4mm (0.012 to 0.016 inch) in diameter.

A superficial microscopic examination showed at once that they were sporozoa. At the time of their discovery I had just found the

intraglobular parasite of Texas fever. Some relation between these intestinal parasites and those of the blood in Texas fever seemed at least a possibility. I therefore gave them as much attention as I could in connection with the somewhat trying microscopic work demanded by the Texas-fever investigations. Subsequently I found the same bodies in cattle from a Washington abattoir. Their relation to the Texas-fever micro-parasite could not, therefore, be upheld any longer, even if their morphology warranted such an assumption, which it does not.

The following observations were made exclusively on fresh material. They are incomplete in many ways, since only the reproductive stage has been seen. They will be continued as opportunity presents, since this group of organisms demands the attention not only of the zoölogist, but of the pathologist as well.*

It has already been stated that the lower portion of the small intestine is the preferred seat of these sporozoa. A few have been detected in the cæcum. They are especially abundant in young animals, and these animals are the only ones which present a sufficient number of stages of the life history of the parasite for investigation. Older animals generally contain a few cysts in an advanced stage of development, but they do not repay examination. I am inclined to regard midsummer as the time when the parasite appears most abundantly, but I have not extended the observations sufficiently into other seasons to make any positive statements on this point.

1. Let us first take the largest cysts readily visible to the naked eye. When crushed under a cover glass in some physiological salt solution the cyst wall tears readily and appears as a very delicate membrane of a finely granular appearance, readily thrown into folds by the crushing. A double contour was not observed. The crushing forces out of the densely packed cyst an immense number of falciform bodies of the same form and size, showing no connection with one another. These swarm spores are from 10.5 to 12.6 μ in length and slightly crescentic in outline (Fig. 2, *a*). The body is homogeneous in appearance. Any differentiation of the cell contents is not observable in this condition. The majority show distinct movements like those originally described by Eimer for the coccidia discovered by him in the mouse's intestine. One end of the crescent bends toward the body, the whole appearing in this condition like the figure 6, or like a hook, or even like the letter U. After remaining in this bent, tetanic state for one or two seconds, the crescent suddenly straightens out, and in some instances it was propelled forward, *i. e.*, in the direction of the other extremity, from one-half to twice its whole length (Fig. 3, *a*). Whether only one-half of the crescent is the contractile portion, or whether both share this function, I am not prepared to say. The power to move had not been lost by

* Dr. C. W. Stiles, zoölogist of the Bureau, will continue the study of this organism.

a stay in the refrigerator for twenty-four hours (55° to 60° F.). The path of the crescent is usually a slightly curved line, corresponding to the curvature of the crescent in its straightened position. In straightening out it may be swung around by this force so as to describe a complete circle. In some cysts forms like *b*, Fig. 3, may be observed moving around this middle point as a pivot without straightening out. In one cyst bent forms with a central knob were observed, which, without showing any change of form, moved quite a distance. In one case the path described by the crescent might be compared to a loop. It will be seen from these illustrations that the motion of these bodies, which can be studied to great advantage in this sporozoön, is by no means easily explained, and will repay careful investigation.

The simple crescents retain their form well in normal salt solution, but when this is replaced by distilled water they speedily assume the spherical form and are disintegrated.

2. Cysts containing independent crescents of the simpler form described (Fig. 2, *a*) are perhaps the most commonly met with. Yet they are not the only ones, for after more or less investigation I found a bewildering variety of cyst contents which will require much patient observation to elucidate their relationship to one another. Not infrequently I found large cysts containing, besides the crescents described, peculiar modifications of the latter, as is shown in Fig. 2. These modifications appear as a central, round finely granular body, about 3μ in diameter attached to the middle point of a thread-like body, the whole being as long as the crescent described (12μ). These sometimes predominate in a cyst, sometimes they are present in small numbers mingled with the others. I have not observed any motion of the slender filiform bodies. It is safe to assume that they are crescents which have undergone further development within the cyst, and that Fig. 2 represents a related series of forms from *a* to *e*, inclusive.

3. In the case of calves minute cysts are frequently detected with a hand lens. Such cysts vary much in the morphology of their contents, and give us some idea of the way in which such a large number of swarm spores may be formed in a single cyst. When such cysts are examined entire under a low power a slight differentiation in the contents may be occasionally detected in the form of minute darker specks (Fig. 1). When the cyst is crushed the outpouring free crescents are accompanied by peculiar agglomerations of crescents. A small spherical body containing a variable number of refracting granules is everywhere beset with the homogeneous crescents first described. Each crescent is attached with one extremity to the periphery of the sphere, and extends radially or somewhat tangentially outwards. Some of these colonies, as they roll out of the crushed cyst, give the impression of sunflowers, the central sphere representing the disk and the crescents the ray flowers (Fig. 4, *a*, *b*). In several cases I was fortunate enough to find a still younger stage of the same structures, as is shown

in Fig. 5. The periphery of a rather large sphere loosely filled with refracting granules is beset with quite short conical appendages, the base resting on the sphere.

In some cysts nearly all the crescents are attached in the manner described. The central sphere varies much in size. The largest may be $15\ \mu$ in diameter, the smallest but $2\ \mu$. The crescents may be so densely packed around the central body as to obscure it almost entirely. In the case of the smaller spheres there may appear but one to three attached crescents.

4. In the contents of the cysts described there are frequently found among the crescents a variable number of round bodies or spheres, from 4 to $9\ \mu$ in diameter, which are filled with minute refrangent particles, and to whose periphery no crescents in any stage of development are seen attached.

5. A few cysts, not more than half the diameter of those described, contained only masses of strongly refracting bodies 1 to $2\ \mu$ in diameter.

From this cursory description it will be seen that only a fragment of the life history of the sporozoön has come under my observation. The youngest stage, its penetration into the tissue of the villus, its true situation there, whether originally as an intracellular or an extracellular parasite, and the form and characters of the adult parasite still need elucidation. That portion of the life history found by me seems to be concerned mainly with the production of a large number of swarm spores. How these are formed in such abundance is shown at least partially by the observations recorded. A large number of centers or foci seem to be present throughout the cyst, from the periphery of which the crescents are produced. The previous history of these foci is not cleared up, but I have seen in various cysts forms roughly reproduced in Fig. 6, which lead me to believe, at least provisionally, that these foci are formed by a simple transformation of some of the crescents into spheres which subsequently produce, peripherally, a second generation of the same elements. In this way we may have several generations of crescents in the same cyst, and the enormous numbers may be the offspring of a few original crescents. As to the correctness of this theory future observations must decide. In several cysts I observed forms resembling *g*, in Fig. 2. The crescent was bent upon itself and apparently within a cyst of its own. Further observations will be necessary to determine whether such endogenous formation of crescents actually takes place. If so, it may represent crescents of a different functional order from those described, and it may explain the presence of the peculiar bent or U-shaped forms (Fig. 2, *f*; Fig. 3, *b*, *c*).

The functions of the swarm spores probably is to keep up the autoinfection of the intestinal mucosa. The rupture of one of the large cysts sends into the intestine a great number of such bodies, each of which is capable of forming a new focus of infection. The different stages in which these cysts are found lends color to this view. It is probable that

there exists also a more resistant stage whose function it is to keep up the life of the parasite outside of the animal body. I am inclined to look upon the tailed modifications of the crescents (Fig. 2, c, d, e), found only in the largest and oldest cysts, as such a resistant stage (*Dauerform*, *Dauerzustand*). The recent investigations of R. Pfeiffer* on *Coccidium oviforme*, and of Schuberg† on *Eimeria falciformis*, have shown that for these coccidia two types of reproduction may perpetuate the species, which in the case of *C. oviforme* were formerly looked upon as two distinct species. It is not to be denied therefore that the supposition concerning a more resistant stage of the crescents given above may be erroneous, and that future investigations may reveal a quite different type of reproduction.

The evidence thus adduced is not sufficient to bring this sporozoön into any of the known groups, but it at least indicates that it does not belong to the Coccidia, and that it has characters which might bring it within the range of the Sarcosporidiæ.

To give an adequate idea of the various stages in which the cyst contents are found, I will cite a few illustrations from my notes:

October 11, 1889.—Several cysts, from small intestine of healthy steer slaughtered for beef, contain only the homogeneous crescents (Fig. 2, a), many in motion.

One cyst contains a variety of forms, from the simple crescent to the knobbed forms (Fig. 2, a to f, inclusive).

September 20, 1889.—Case of Texas fever. One cyst contains mainly forms shown in Fig. 6.

September 20, 1889.—One cyst, from intestine of healthy steer, contains only such forms as are shown in Fig. 4. All crescents are attached to spherical bodies of various dimensions (2μ to 15μ).

A second cyst from the same animal contains free crescents in motion and a small number of round granular bodies (Fig. 5, a).

August 20, 1890.—One cyst, from a calf which succumbed to Texas fever, contains an immense number of refracting granules, 1μ diameter, and many spherical bodies with small crescents attached (Fig. 5). Whether the free granules were originally contained in small cysts and freed by crushing was not determinable.

A second cyst contains, besides a few sunflower forms (Fig. 4), an immense number of free crescents.

A third very small cyst contains only refracting granules, 1 to 2μ in diameter.

September 22, 1890.—One cyst, from a calf killed after a mild attack of Texas fever, contains motile crescents and granular spheres (4 to 9μ in diameter).

A second cyst contains only knobbed crescents in the stage of b, Fig. 2.

A third small cyst contains almost exclusively immature attached crescents (Fig. 5, b, c, d, e).

August 11, 1890.—One cyst, from a healthy slaughtered steer, contains mainly tailed (Fig. 2, d, e, f) forms and a few crescents.

A second cyst contains (1) homogeneous crescents in motion; (2) tailed or knobbed forms; (3) many crescents bent in form of the letter U (Fig. 2, f); (4) crescents attached to a central sphere; (5) forms like Fig. 2, g.

A third cyst contains crescents only. These are of the usual form or doubled up (U-shaped) or partly extended. The U-shaped forms are quite abundant.

* Untersuchungen über Protozoen, Heft. 1, 1892.

† Ueber Coccidien des Mäusedarmes. Sitzungsber. d. Würzb. phys-med. Gesellschaft, 1892.

DESCRIPTION OF PLATE I.

Illustrations, somewhat diagrammatic, of the various observed forms of the sporozoön. Fig. 1 is magnified about 80 diameters, the rest, 1,000 diameters.

Fig. 1. Cyst as seen under a low power of the microscope. The darker spots represent the forms shown in Fig. 4. The remainder of the cyst is filled with free crescents.

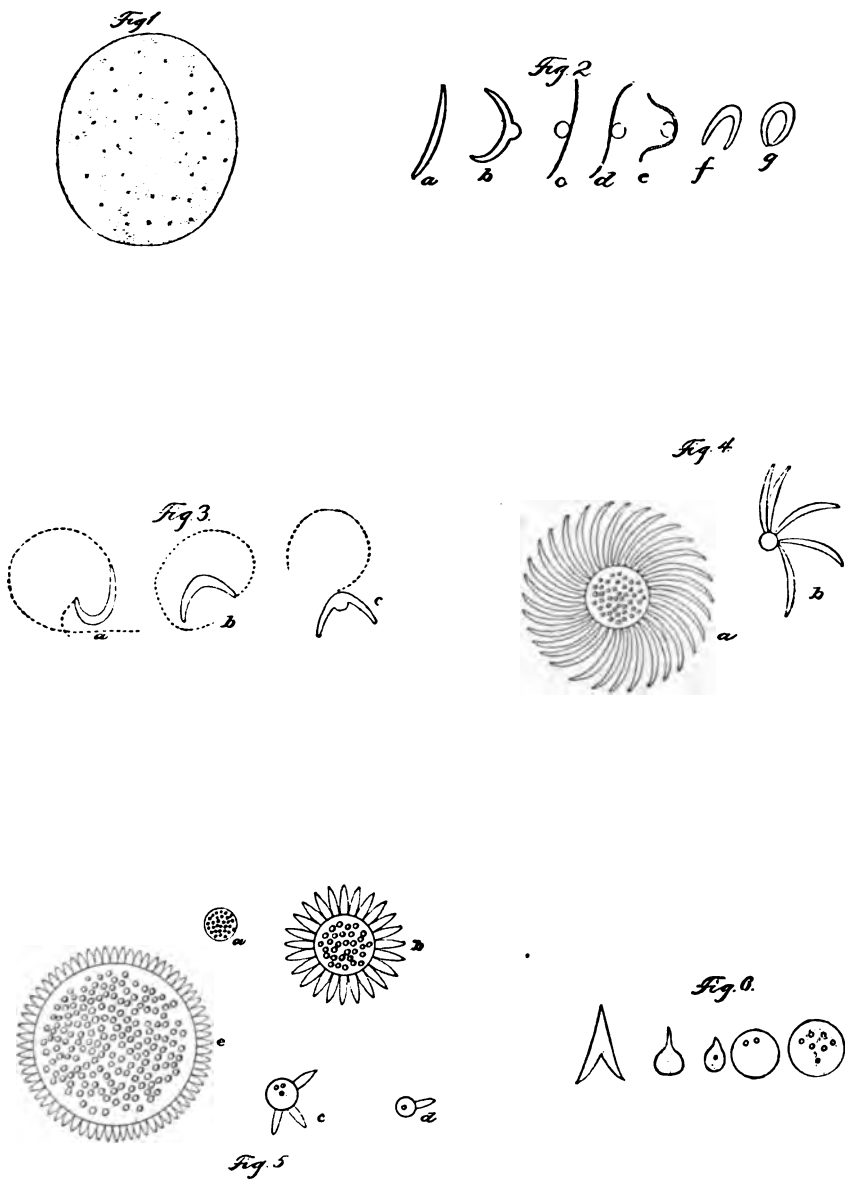
Fig. 2. Crescents of various forms.

Fig. 3. Crescents in motion. The dotted lines indicate approximately the paths.

Fig. 4. Spheres containing granules, with periphery beset with nearly mature crescents.

Fig. 5a. Simple sphere containing granules; *b*, *c*, *d*, and *e*, spheres with periphery beset with immature crescents.

Fig. 6. (Hypothetical), transformation of a crescent into a sphere.



SPOROZOÖN IN THE INTESTINAL VILLI OF CATTLE.

NOTES ON PARASITES—13: ON THE PRESENCE OF SARCOSPORIDIA IN BIRDS.

By C. W. STILES.

[Plates II and III.]

The first reference I have been able to find in regard to Sarcosporidia in birds is an article by J. Kühn.* This paper is unfortunately not at my disposal, but it is evident from the statements of later authors that Kühn found the parasites in chickens.

Riley† examined a duck whose muscles were infested with parasites one-fourth to one-fifth of an inch long; they resembled grains of wheat and contained a viscid yellowish substance. Riley compared them to pork measles (*Cysticercus cellulosæ*) and was under the impression that they represented the larval stage of some worm which would reach maturity in the intestine of man. Upon seeing one of the specimens I describe below, Riley stated to me that it was undoubtedly identical with his duck measles.

Bélanger‡ presented before the Société d'Histoire Naturelle de Quibec a case of parasitism in *Spatula clypeata* Boie. Small "white worms" were found by thousands in the muscles. They measured $\frac{1}{2}$ –1 line long, and appeared to belong "à quelques genres voisins des trichines, bien qu'ils ne fussent pas enroulés, ni renfermés dans des enveloppes." This reference, to which Prof. Riley called my attention, probably refers to the same parasite described below from the same host.

Rivolta§ states:

Gli otricelli psorospermici dei gallinacci, di cui fanno menzione alcuni trattatisti (Röll ecc.) altro non sono che gli otricelli del Miescher o del Renay, che non si devono confondere con i psorospermi, propriamente detti, dei polli.

On page 398, *l. c.*, in discussing *Enterite psorospermica*, he adds:

Alle pareti poi dell' intestino si scorgono, situati all' incirca nel sottomucoso, dei punti bianchicci sparsi qua et là; quasi tutti della grandezza di un seme di papavero o di un semplice punto. Questi punti bianchicci non sono formati da colonie di psorospermi ma bensì da otricelli del Miescher o del Renay pieni di navicelle.

Rivolta also gives two figures of the parasites.

*Mittheilungen d. landwirthsch. Instit. zu Halle, 1865, p. 68.

†Walsh and Riley. A Measly Wild Duck. The American Entomologist, 1869, 1, p. 89.

‡Le Naturaliste Canadien, Tome II, Mai, 1870, p. 188.

§Dei parassiti vegetali, Torino, 1873, p. 393, Taf. III, figs. 52, 74.

Leidy* describes some cysts found in the interstices of the muscles of *Anas boschas* L. They were oval, white, 2 to 4 mm. long, 0.7 mm. thick, and contained myriads of "fusiform corpuscles" 17μ long, resembling minute pseudo-navicellæ. He adds that "though the Mallard is not a fish eater, the bird may have become infected by eating diseased fish." Thus it is clear that Leidy was inclined to look upon these parasites as identical with the Myxosporidia.

Leuckart† simply states in regard to Sarcosporidia in relation to birds, "selbst das Haushuhn bleibt davon nicht verschont."

Bütschli‡ refers to the observations by Kühn and Rivolta as follows:

Kühn§ fand sie auch bei Hühnern und Rivolta hat auf das Vorkommen ähnlicher Parasiten in der Submucosa des Darmes mehrerer Vögel (der Haushühner, Schwarz-amsel (*Turdus merula*), des Rabens, etc., aufmerksam gemacht und es scheint auch, dass dieselben mit Recht den parasitischen Schläuchen der Säugethiere an die Seite gesetzt werden.

Zürn|| states that Sarcosporidia (*Psorospermischläuche*) have been reported in the muscles, kidneys, and intestinal walls of various birds. He himself had never found them. The parasites are in some cases microscopic, in others visible to the naked eye; they may be 1 or several mm. long and are surrounded by a resistant but porous membrane. The crescents are 0.01 mm. long and contain one or more vacuoles, together with granules. They are not scattered regularly through the entire cyst, but collected together in balls.

Barrows¶ found a *Parula pitiayumi* (Vieill.) whose muscles were parasitized, and upon examining one of my specimens Mr. Barrows said that the parasite appeared identical with those he found, so far as this could be determined without a microscopical investigation. His description reads:

One specimen (*i. e.*, *Parula pitiayumi*) seemed to be abnormal in coloring, showing many white feathers in the forehead, and upon skinning the flesh was found thickly spotted with oval, white lumps about the size of the egg of the common blow-fly. These were most numerous toward the surface of the pectoral muscles, but occurred also deeply imbedded in their substance as well as in the muscles of wings and legs. It was not practicable to examine their structure with the microscope until the next day, when decomposition was so far advanced that little could be made out. In all probability, however, they were the encysted larvæ of some parasitic worm, though whether they had anything to do with the abnormal plumage is an open question.

Barrows' description renders it almost certain that this was a case of sarcosporidiosis, although it is, of course, impossible to determine

* *Psorosperms* of Mallard Duck. Proc. Acad. of Science, Phila., 1875, XXVIII, p. 125.

† Die Parasiten des Menschen, 2. Aufl., 1879, I, p. 254.

‡ Protozoa, I, p. 605. Bronn's Klassen und Ordnungen des Thier-Reichs, 1880-'82.

§ Sopra i vajuolo dei Columbi e dei Polli. Giornale di Anatomia, Fisiologia e Patologia degli Animali, 1874, VI, p. 257. (N. B.—The pagination of this journal is incorrect. It should read, p. 321.)

|| Die Krankheiten des Hausgeflügels, 1882, p. 146.

¶ Walter B. Barrows. Birds of the Lower Uruguay. Bull. of the Nuttall Ornithological Club, VIII, 1883, p. 87.

whether the parasites were identical with any of the forms described below or not. From the size of the animal ("the size of the eggs of the common blow-fly", *Lucilia cæsar*) it is probable that the parasites belonged to the genus *Balbiania*.

R. Blanchard* does not believe that the parasites mentioned by Rivolta in chickens are Sarcosporidia, but rather that they belong to *Eimeria*.

Mr. Haines, artist, upon seeing my specimens, said that he had noticed this same parasitized condition of the pectoral muscles in chickens upon several occasions, while Prof. C. Hart Merriam, of this Department, tells me that he has not infrequently seen similar bodies in the muscles of various birds.

I have mentioned above all the references I have been able to trace here at Washington of parasitic Sarcosporidia in birds.

While this list may not be entirely complete, it is quite evident that this parasitism, although by no means rare, has attracted very little attention, and that we have as yet no exact description of any one species of Sarcosporidia in birds. On this account I have deemed it advisable to place on record several cases of this kind which have recently come under my observation, and to give a more or less minute description of the animals, so far as the condition of the material at hand will permit.

1. The U. S. National Museum, through Prof. Riley, has recently referred to this Bureau a portion of the pectoral muscles of the Shoveller or Spoon-billed Duck (*Spatula clypeata*), taken by Walter Brett at Clear Lake, California.

2. From the U. S. Army Medical Museum I have a specimen of parasitized muscle labelled "*Cysticerci* (?) from the Shovel-bill Duck." (*Sp. clypeata*).

3. In our own collection in the Bureau of Animal Industry we possess a specimen labelled "From ducks. Prof. Lüger, Minnesota, said that falciform bodies escaped from cysts like *Balbiania gigantea*."

4. In Leidy's collection of parasites, which the University of Pennsylvania has recently sent to me for revision, I have found a bottle containing a portion of muscle labelled "Oval, smooth bodies, no limbs. In muscles of Mallard. *Anas boschas*. Dr. E. Coues. Ex. Jan. 26, 1890."

5. Finally, a second bottle referred to me by the U. S. National Museum contains the legs of a Grosbeak (*Habia ludoviciana*). The label reads "Explorations in Manitoba, Walter Brett. *Habia ludoviciana* ♂ (1166). Riding Mountain, June 16, 1892."

An examination of the muscle in all cases shows that it contains numerous elongated cysts lying parallel to the muscle-fibers and perfectly visible to the naked eye. The parasites found in specimens 1 to

*Note sur les Sarcosporidies et sur un Essai de Classification de ces Sporozoaires. Bull. d. l. Soc. Zool. d. France, 1885.

4 are identical, while two different forms of Sarcosporidia are found in specimen 5.

1. Balbiania Rileyi sp. n., 1893.

[Plate II, Figs. 1-5.]

The parasites in specimen 1 are in a tolerably good state of preservation, while specimens 2 to 4 are not so well preserved. They measure 1 mm. to 6 mm. in length, 0.48 mm. in diameter in their middle. They are rather fusiform, but the ends are somewhat blunt. Coloring liquids differentiate the body into two distinct portions—a center core, which has the general form of the entire body and is about 0.16 mm. broad in its greatest diameter, and a peripheral portion having about the same thickness as the center core. In some specimens the peripheral zone is even broader than the central core. The meshes of the central core may either be empty or contain a granular matter which does not take stain; while the meshes of the peripheral layer are filled with numerous lancet or falciform bodies, to the staining of which is due the differentiation of the entire body into the center core and peripheral layer.

The falciform bodies measure 12 to 14 μ long by 2 μ broad. They are slightly more pointed at one end than at the other. They contain a distinct oblong nucleus (about 2 μ) which stains (Figs. 4, 5) very clearly with methyl blue or acid carmine. On unstained preparations (Fig. 5, b) the nucleus appears as a bright refragent body. Its position is not constant. The rest of the falciform body is granular. Occasionally a small but indistinct vacuole is noticed.

The outer covering of the Sarcosporidium is a very thin (2 μ) cuticular membrane. In this no striation could be discovered. The entire inner portion of the animal is a meshwork or stroma, in the interstices of which lie the numerous falciform bodies. Although there is no regular arrangement or form to the meshes of this stroma, in general they radiate from the center to the periphery and are longer (*i. e.*, in a radial direction) than broad (*i. e.*, in a tangential direction).

The entire stroma can be separated from the cuticle and pressed out, but I was unable to isolate the meshes one from another. Treated with a strong solution of caustic potash the contents of the meshes were destroyed. The walls, however, remained intact. In nearly all cases the wall between any two adjacent meshes appeared to be a simple membrane, common to both lumina, but in one or two cases the walls split longitudinally for a short distance, thus giving the impression that each lumen possessed its own wall and that the adjacent walls of the two meshes were very intimately united. In places where three meshes came together at one point there was frequently a triangular space between the three membranes.

The parasites lie between the muscle-fibers, surrounded by connective tissue. A very careful examination of a number of microtome sections failed to show any young stages inside of the muscle-fibers.

It is evident from the above that this parasite is very closely allied to

Balbiana gigantea Railliet, and *B. mucosa* R. Bl. Placing it in the genus *Balbiana*, I propose the specific name *B. Rileyi*, dedicating the species to my colleague, Prof. C. V. Riley, Entomologist of the United States Department of Agriculture, as he is evidently the first scientist who examined this parasite.

Diagnosis.—*B. Rileyi*, sp. n., 1893. 1-6 mm. long by 0.48 mm. broad; rather fusiform, ends not sharply pointed. Cuticle not striated, about 2μ thick. Center core does not color and does not contain falciform bodies. Peripheral zone as broad as central core (0.16:0.16 mm.) or even broader; colors in various liquids (acid carmine or methyl blue), and contains numerous falciform bodies. Form of meshes irregular, but elongated radially. Falciform bodies 12 to 14μ long, more pointed at one extremity than at the other; contain a very distinct nucleus (2μ) which stains clearly in acid carmine or methyl blue, and which contains several chromatophil granules; vacuole quite indistinct.

Habitat.—Intermuscular connective tissue of ducks (the Shoveller or Shovel-bill Duck or Spoon-bill Duck (*Spatula clypeata*) and the Mallard Duck or Tame Duck (*Anas boschas*).

Development unknown.

Geographical distribution.—North America. (?) Philadelphia, Pa. (Coues-Leidy); St. Louis, Mo. (Riley); Clear Lake, Cal. (Brett); Minnesota (Lüger); Quebec (Bélanger).

Type material deposited in the U. S. National Museum, in the Bureau of Animal Industry, and in Collection of Stiles, Washington, D. C. Specimens are also to be found in the Army Medical Museum, Washington, D. C., and in Collection of Leidy, University of Pennsylvania, Philadelphia, Pa.

In conclusion, although "measly duck" is not very appetizing in appearance, there are no grounds for believing that it is dangerous to man.

Specimen 5, mentioned above, contained, as already stated, two different forms of Sarcosporidia, which could easily be seen through the skin of the animal. The difference between the two forms, however, could be recognized only in microscopic preparations. One form was thicker, the cuticle unstriated so far as I could discover, a central non-staining core was present, and the parasites were intermuscular. The other form was much thinner, possessed a transversely striated cuticle, contained no central non-coloring core, and the parasites were intramuscular, *i. e.*, inside of the muscular fibers.

Blanchard (*l. c.*) has proposed the following provisional classification of the Sarcosporidia:

I. Family *Miescheriæ*:

Situated in the striated muscles, enveloping membrane—

- a. Thin and structureless..... *Miescheria*.
- b. Thick and traversed by fine canals..... *Sarcoecystis*.

II. Family *Balbaniæ*:

Situated in the connective tissue, enveloping membrane thin and

without structure *Balbiana*.

I have already stated * that I agree with those authors who consider that the membrane of *Sarcocystis* is finely striated, instead of possessing pores—there can be absolutely no doubt in regard to this point in *S. tenella* of sheep—so that according to Blanchard's classification, if we substitute "finely striated" in place of "traversed by fine canals," the thicker specimens mentioned above will belong to the genus *Balbiana*, while the thinner form must be placed in the genus *Sarcocystis*.

Finding, as I have, the two forms lying side by side in the same host, there are two alternatives open to us to explain their presence:

(1) Either we have here a case of infection by two Sarcosporidia of different genera; or (2) *Sarcocystis* is only a younger intramuscular stage of the intermuscular *Balbiana*.

Although the second explanation is very tempting to us, yet having but a portion of a single animal infested with the two forms now under consideration, it would be too hazardous for me to state that this is the correct explanation, and to attempt to prove it, especially as the following facts can not be considered confirmatory of this view:

(1) In the case of *B. Rileyi*, I have found no intramuscular stage.

(2) In the horse, sheep, and hogs, it is a very common occurrence to find only intramuscular Sarcosporidia.

Thus, for the present, I feel compelled to place the two forms now under consideration in two separate genera, *Sarcocystis* and *Balbiana*, respectively, although I will give to both the same specific name, so that they may more easily be united in case they prove to be two stages of the same species.

2. *Balbiana falcatula* sp. n., 1893.

[Plate III, Figs. 1-2.]

This form appears quite distinct from *B. Rileyi*, in that it is longer in proportion to its breadth; the central non-coloring core is much wider in proportion to the peripheral coloring portion; the meshes in the center core are smaller and more regular, while the meshes of the peripheral zone generally have a more regular outline; the falciform bodies are only about half as large (6μ) as those of *B. Rileyi*, and generally more curved; they possess a very prominent nucleus, but no vacuole or portion resembling a vacuole could be discovered, except that the middle portion stained more lightly than the ends.

Specific diagnosis.—*B. falcatula* sp. n., 1893. The parasites measure 1.3 mm. to 3.2 mm. long by 0.4 mm. to 0.42 mm. broad; fusiform; cuticle not striated, about 2μ thick. Center core does not color, and contains no falciform bodies; meshes quite regular, 8μ to 12μ . Peripheral zone much narrower than centre core (0.096 mm. : 0.224 mm.), colors in various liquids (acid carmine, for instance) and contains numerous

* Review of recent publications in Medical Zoölogy. The Journal of Comparative Medicine and Veterinary Archives, 1891, p. 693.

falciform bodies measuring 5μ to 6μ long by 2μ broad; the latter curved, containing a distinct nucleus (1.5μ) generally situated at one end; no vacuole visible (alcohol material).

Habitat.—Intermuscular connective tissue of the Rose-breasted Grosbeak (*Habia ludoviciana*).

Development unknown.

Geographical distribution.—North America, Manitoba (Brett).

Type material deposited in the U. S. National Museum, in the Bureau of Animal Industry and in Collection of Stiles, Washington, D. C.

3. *Sarcocystis falcicula* sp. n., 1893.

[Plate III, Fig. 3.]

These parasites lie within the sarcolemma; they measure on an average 2.4 mm. long by 0.152 mm. broad; the ends are pointed, the membrane (3μ thick) is finely striated; no non-coloring central core could be distinguished. At the extremities the divisions or meshes in which the falciform bodies lie are more rounded and distinct, but near the middle of the body it is almost impossible to recognize these divisions. The falciform bodies I could measure only on microtome sections. They appeared about 6μ long.

Specific diagnosis.—*S. falcicula* sp. n., 1893. Body 2.4 mm. long by 0.152 mm. thick; fusiform; cuticle finely striated; meshes at extremities rounded and distinct, in middle portion indistinct; falciform bodies 6μ long.

Habitat.—Muscle-fibers of *Habia ludoviciana*.

Life history unknown.

Geographical distribution.—North America, Manitoba (Brett).

Type material deposited in the U. S. National Museum, in the Bureau of Animal Industry, and in Collection of Stiles, Washington, D. C.

Species inquirendæ.

4. Sarcosporidia of chickens found by Kühn (1867), at Halle, Germany, and by Haines (cited above) in Maryland, U. S. A.

5. Sarcosporidia—probably *Balbiana* sp. found by Barrows in *Parula pititayumi*, at Concepcion del Uruguay, province of Entre Rios, Argentine Republic, South America.

6. ? Sarcosporidia described by Rivolta (1874) from chickens, *Turdus merula* and crows (cited from Bütschli).

DESCRIPTION OF PLATE II.

Fig. 1. A portion of the pectoral muscles of a duck (Measly duck).

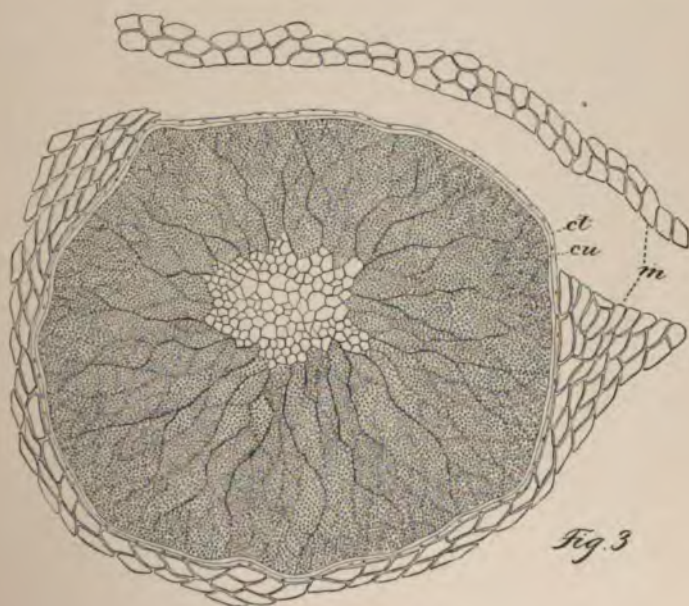
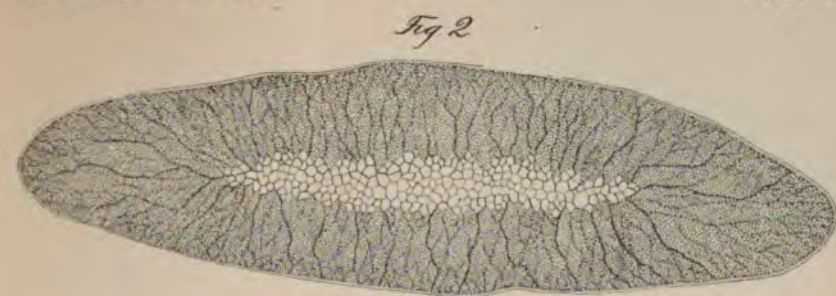
Fig. 2. Longitudinal section of *Balbiania Rileyi* (greatly enlarged).

Fig. 3. Transverse section of *Balbiania Rileyi* (greatly enlarged); *ct*, connective tissue cyst, with numerous nuclei; *cu*, cuticle of the parasite; *m*, sections of muscle.

Fig. 4. Microtome section of meshes containing falciform bodies, greatly enlarged.

Fig. 5. Falciform bodies of *Balbiania Rileyi*; *a*, stained, showing nucleus and vacuole; *b*, unstained.

All drawings by Mr. Haines, artist, detailed to this Bureau, drawn either from nature or after sketches by author.



BALBIANIA RILEYI sp. n.

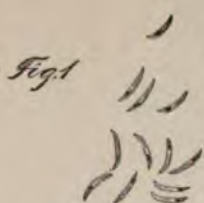
DESCRIPTION OF PLATE III.

Fig. 1. Falciform bodies of *Balbiania falcatula*.

Fig. 2. *Balbiania falcatula*, longitudinal section.

Fig. 3. *Sarcocystis falcatula*, longitudinal section. It will be noticed that the ends of the parasite are included in a muscle-fiber which has lost part of its transverse striation. In the specimen here drawn the muscle-fiber could not be traced the entire length of the parasite.

Fig. 3a. A portion of the striated cuticle, seen on section.



BALBIANIA FALCATULA sp. n., and SARCOCYSTIS FALCATULA sp. n.





U. S. DEPARTMENT OF AGRICULTURE.
BUREAU OF ANIMAL INDUSTRY.
BULLETIN No. 4.

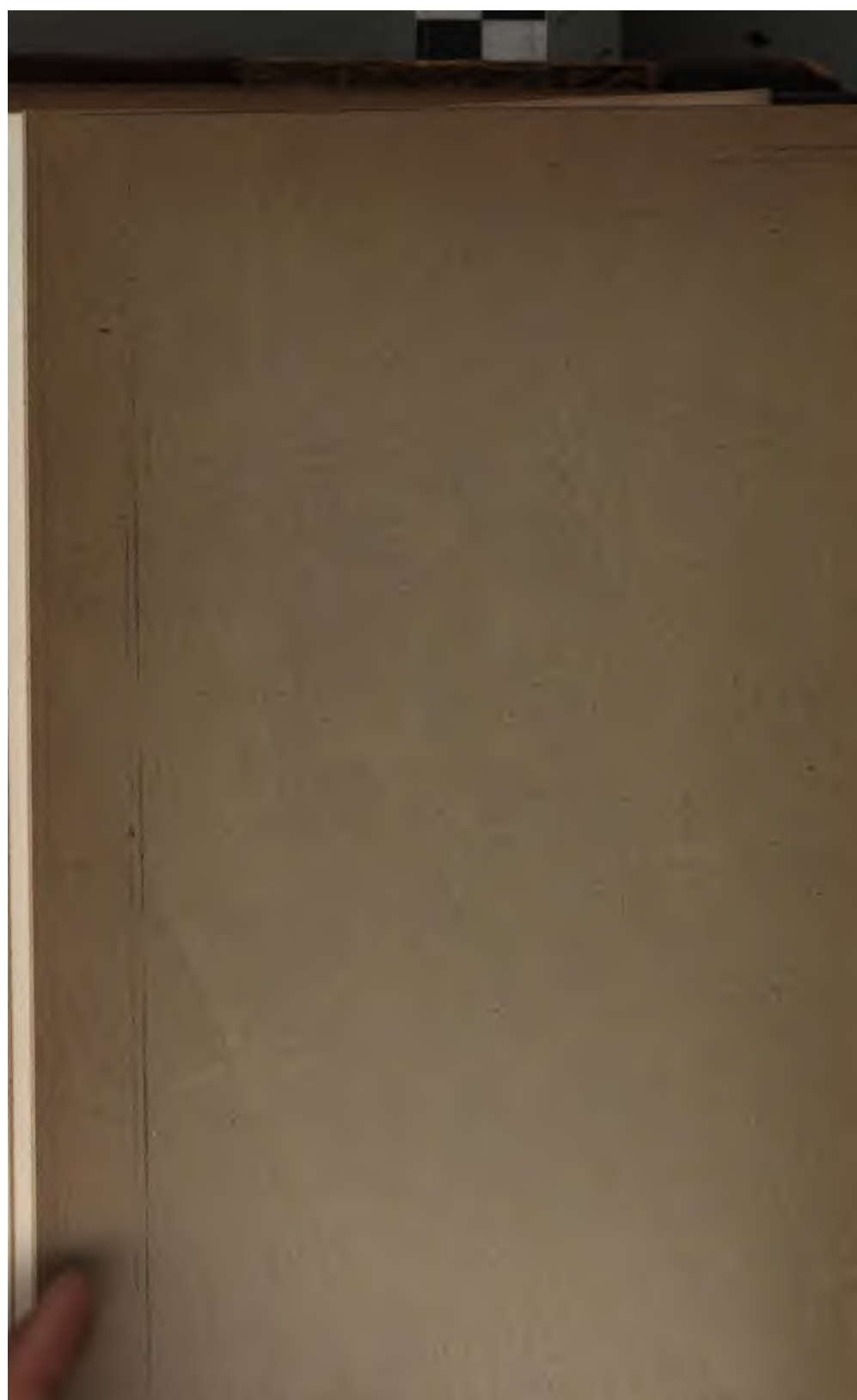
A REVISION OF THE ADULT CESTODES
OF
CATTLE, SHEEP, AND ALLIED ANIMALS.

PREPARED UNDER THE DIRECTION OF DR. D. E. SALMON, CHIEF OF
THE BUREAU OF ANIMAL INDUSTRY.

BY
C. W. STILES, PH. D., AND ALBERT HASZALL, M. R. C. V. S.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1893.



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., September 15, 1893.

SIR: I have the honor to transmit herewith a report covering "A Revision of the Adult Cestodes of Cattle, Sheep, and Allied Animals." It has long been known that herbivorous animals were subject to infection by tapeworms, but it was not known exactly how many different species were to be found, nor has it heretofore been definitely known what particular species were present in America. Since it may be assumed that every separate species of tapeworm found in animals has a separate source of infection, it has been deemed important to obtain definite data for the determination of the various species already described and to give descriptions of the new forms found in this country. With this end in view, the original type specimens of European species were re-studied according to the more modern scientific methods before the American forms were investigated. The manuscript herewith transmitted covers the results of a more thorough and extensive study of the tapeworms of cattle and sheep than has ever before been attempted, and places the forms mentioned on a scientific foundation.

Very respectfully,

D. E. SALMON,
Chief of Bureau.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., April 18, 1893.

SIR: In accordance with instructions received from you to prepare a report on the animal parasites of cattle, I began the work in September, 1891. In the spring of 1892 I took up the tapeworms of cattle, and found that the various diagnoses of the species given by different authors were so contradictory that it was almost impossible to determine a single species with certainty. I was convinced that it was useless to write anything on the subject for my report until the entire group of tapeworms found in cattle and allied animals was subjected to a thorough anatomical study in order to obtain definite characters for the differentiation of the various species.

During the course of the anatomical study then begun I obtained a number of interesting results which are too technical to publish in the biennial report of this Bureau, and yet too valuable to zoölogists and veterinarians and too important theoretically to leave unpublished. These results, therefore, have been included in this manuscript, which I offer for publication as a special bulletin.

In this study I have confined myself almost entirely to the microscopic anatomy of those organs which would be of systematic value. No pretensions are made in this publication to treating the worms histologically, although here and there I have mentioned a few histological observations.

As it was impossible to determine the various species with certainty from their present diagnoses, I obtained the original type specimens of a number of the parasites in question, and have made my specific determinations by comparing the worms in the Bureau collection directly with the type specimens. I have further received from various European specialists a number of tapeworms which I have compared with our American forms, and it is a pleasant duty to acknowledge the kindness of these foreign specialists in sending me the specimens referred to. To Geheimrath Prof. Dr. Karl Möbius, Director of the Berlin Museum, I am indebted for segments of the original *Tania expansa* and *Tania denticulata* described by Rudolphi in 1810; to Prof. L. G. Neumann, of the National Veterinary School at Toulouse, France, I am indebted for specimens of *Moniezia planissima*, *M. alba*, *M. trigonophora*,

T. Giardi, *T. centripunctata*, and *T. globipunctata*; to Prof. Moniez, of the Medical Faculty of Lille, France, I am indebted for the original material of the parasites described by him under the names: *T. Giardi*, *T. Benedeni*, *T. Neumanni*, and *T. nullicollis*, as well as for specimens of other French tapeworms; to Prof. Railliet, of the Veterinary School of Alfort, France, I am indebted for specimens of *M. planissima*; to Prof. R. Blanchard, of Paris, France, I am indebted for specimens of *Tania marmotæ*, which I wished to compare with the above-mentioned forms found in cattle and sheep; to Dr. von Marenzeller, of Vienna, I am indebted for a specimen of *M. Benedeni*; to Prof. Perroncito, of Turin, Italy, I am indebted for three strobilæ of his original material from which he described *Tania alba*; to Dr. G. M. Giles, of Sanawar, Punjab, India, I am indebted for specimens of *Tania globipunctata*.

Besides the above-mentioned specimens I have had at my disposal the entire Bureau collection of tapeworms of cattle and sheep, over 800 in number, collected by Dr. Curtice, Dr. Hassall, and myself; also a number of specimens from Dr. Hassall's private collection, made in England, and from my own collection of parasites, made in France, Germany, Austria, and America.

I wish to acknowledge, also, the services of my assistant, Dr. Hassall, who has made about 2,000 microscopic slides for my use.

For that portion of this bulletin which deals with new species and for the bibliography at the end of this paper, both Dr. Hassall and myself are to be considered responsible, while I alone am responsible for the statements made in regard to the species already known.

According to the rules passed by the International Zoölogical Congress, Paris, 1889, the law of priority must be strictly adhered to in determining the generic and specific names of animals. Most zoölogists have adopted this rule, although it occasionally causes inconvenience for the time being. In a former paper I objected to applying the rule in all cases, stating, as a particular case, that we should speak of *Pentastomum proboscideum* rather than revert to the specific name *crotali*. At present, however, I wish to withdraw from that position, for I am thoroughly convinced that we can never obtain a fixed nomenclature until the "law of priority" and the rule "Once a synonym always a synonym" are strictly enforced according to the rules laid down by the International Congress. I am hence in favor of speaking of *Linguatula* rather than *Pentastomum*, and if the genus *Linguatula* is divided we are obliged to accept the genera, *Linguatula* and *Porocephalus*—*Porocephalus crotali*, instead of *Pentastomum proboscideum*.*

*We should in that case speak of *Porocephalus constrictus*, *Por. annulosus*, *Por. polyzonus*, *Por. subuliferus*, *Por. moniliformis*, *Por. megastomus*, *Por. oxycephalus*, etc. It is not at all improbable that *Porocephalus armillatus* (*Linguatula armillata* Wyman, 1845) will prove to be identical with *Porocephalus polyzonus*, in which case Wyman's specific name must be accepted. I hope later to compare the type specimens of some of these forms in order to straighten out the synonymy, which seems at present to be very uncertain.

In the present paper I have held strictly to these rules, and used the terms *actinioides* and *Giardi* as specific names, instead of *fimbriata* and *ovilla* in speaking of two of the worms found in sheep.

I am well aware of the fact that in following out these rules I am doing that which, although indorsed by most zoölogists, is disapproved of by many helminthologists, who contend that we should accept the specific name which we find in general use. These authors, however, lose sight of the fact that many animals have one name in general use in one country, while another name is generally used in another country. Thus *Pentastomum* is in general use in Germany, while *Linguatula* is in more general use in France, England, and America. Authors are generally best acquainted with the text-books of their own country, and will naturally assume that the name "in general use" in their own country is the name to be followed. Thus Germans would hold to *Pentastomum*, while French, English, and American authors would hold to *Linguatula*.

The only way to establish an international nomenclature in medical zoölogy, as well as in other branches of biology, is to enforce the law of priority.

In the adult tapeworms of cattle and allied animals I recognize several distinct groups, and in the description given below the parasites are classed together in four groups:

(1) Blanchard's genus *Moniezia*, in which the species naturally fall into three subdivisions:

(a) The *Planissima* group, characterized by the linear arrangement of the interproglottidal glands (*M. planissima*, *M. Benedeni*, *M. Neumanni*).

(b) The *Expansa* group, characterized by the sacular arrangement of the interproglottidal glands (*M. expansa*, *M. oblongiceps*, and *M. trigonophora*).

(c) The *Denticulata* group, which contains forms in which the interproglottidal glands are absent (*M. denticulata* and *M. alba*).

(2) The genus *Thysanosoma* Diesing. This genus is characterized by the presence of a single uterus with ascon-spore shaped egg-sacs. Further, while in the genus *Moniezia* the genital canals pass dorsally of the longitudinal canals, in the genus *Thysanosoma* they pass between the longitudinal canals.

(3) Railliet's new genus *Stilesia*, based upon *Tania globipunctata*. Provisionally the species *T. centripunctata* may be placed in this genus, but I believe that further study may result in the formation of a separate genus for that worm.

(4) Owing to our lack of knowledge of the anatomical details of *M. nullicollis*, *T. Fogli*, *T. crucigera*, *T. capreoli*, and *T. caprae*, it is impossible as yet to give these species any definite place in the classification.

Besides the above-mentioned species, the Bureau possesses three forms of *Moniezia*, taken from sheep, at least two of which are probably new species.

Unless otherwise expressed the measurements given are in millimeters (mm).

The cestodes collected by this Bureau for the past eighteen months have been fixed in the following solution: Fifty parts of an aqueous solution of corrosive sublimate + 50 parts of alcohol, 70 per cent + a few drops of glacial acetic acid. The worms were placed in this liquid

which had been heated to 45-53° C. The liquid was then allowed to cool for 20 to 60 minutes. The parasites were next washed in running water from 1 to 24 hours, and passed through 30 per cent, 50 per cent, 70 per cent, 95 per cent, and absolute alcohol.

The preparations have been colored in alcoholic hydrochloric acid-carmines after Grenacher or hæmatoxylin, and finally mounted in Canada balsam. Most of the specimens collected by the Bureau prior to July, 1891, were simply preserved in alcohol, and, with few exceptions, have been of very little use in preparing this bulletin. It is also evident that the specimens we have received from European zoölogists have been killed in alcohol.

Anterior in this paper signifies cephalad.

Posterior signifies caudad.

Proximal refers to the direction toward the head or median line.

Distal refers to the direction from the head or median line.

Ventral refers to the flat surface of the worms, containing the large longitudinal canals and female organs.

Dorsal refers to the opposite surface.

Lateral refers to the direction toward the margins upon which the genital pores are found.

Respectfully submitted.

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A REVISION OF THE ADULT CESTODES OF CATTLE, SHEEP, AND ALLIED ANIMALS.

By C. W. STILES, PH. D., and ALBERT HASSALL, M. R. C. V. S.

PART I.

MONIEZIA R. Blanchard, 1891.

A. Planissima Group. (*M. planissima*, *M. Benedeni*, and *M. Neumanni*.)

Interproglottidal glands linear and not grouped around sacs.

(1) *Moniezia planissima* Stiles and Hassall, 1892.

[Plates I, II, Figs 1-6; Plate III.]

Synonymy.—*Tania expansa*, ex parte of various authors.

Hosts.—Sheep (*Ovis aries*); cattle (*Bos taurus*); small intestine.

Geographical distribution.—United States of America: Chicago, Ill., and Washington, D. C. (Hassall, Stiles, and Curtice); Fairfax County, Virginia (Norgaard).
France: Paris (Railliet, of Alfort, Stiles); Toulouse (Neumann).

LITERATURE.

(Probably all references to *Tania expansa* 20-25^{mm} broad.)

- (1) C. W. STILES. Notes sur les Parasites—14: Sur le *Tania expansa* Rudolphi; Compt. rend. de la Soc. d. Biol. Paris, 1892. Pp. 665-666.
- (2) ———. Bemerkungen über Parasiten—17: Ueber die topographische Anatomie des Gefässsystems in der Familie *Toniada*; Centralblatt für Bakteriologie und Parasitenkunde. 1893. Bd. XIII, p. 457-465, Fig. 3.

HISTORICAL REVIEW.

Upon studying the tapeworms of cattle and sheep we became convinced that *Moniezia expansa* contained more than one species, and diagnosing the proper *M. expansa* by a few segments and the scolex of Rudolphi's original material, we separated from it *Moniezia planissima*. Stiles found this species at Paris, and Hassall and Stiles found it at Washington, D. C. We have also found several segments of this worm in the material collected by Dr. Curtice, under the label "*Tania expansa*," and Dr. Norgaard has recently found it in Virginia. Two of the best known medical zoölogists of France (Railliet and Neumann) have also sent us specimens of this species under the label "*Tania expansa*."

The only publications on this worm, as a distinct species, are the short preliminary notes by Stiles (1, 2). The present account of the anatomy is the paper anticipated by those preliminary papers.

General appearance.—When fresh the strobila is yellowish, but when preserved it becomes whitish. The worm is remarkably flat and broad much more so than *M. expansa*. In the best specimens at our disposal the segments are slightly contracted. In a few specimens in the Bureau collection they are not contracted, the segments being slightly longer and narrower. In the following description, however, we have used the worms which are slightly contracted. Nevertheless, we have given a figure of some uncontracted segments, so that the difference may be readily seen and no confusion arise.

Fig. 1, Plate I, represents a strobila, natural size, slightly contracted. The segments increase in breadth very rapidly. It will be noticed that the segments are very regular, although wedged segments, such as have been described in other worms, are occasionally found. The posterior flap of the segment, overlapping the next following segment, is very distinct. The cuticle is very smooth.

Scolex.—The heads of the various preserved specimens in our possession vary greatly in shape and size. They have the appearance presented in Figs. 2, 2a and 2b, Plate I. When viewed from the apex the head is nearly square. The suckers are at the four corners and turned slightly towards the front. In press preparations, viewed from the ventral or dorsal surface, we notice a plane running from the anterior portion backwards and upwards, *i. e.*, the posterior edge of this plane is the point of the highest focus, and situated 0.56 mm from the anterior extremity. A head examined in alcohol measured 0.8 mm broad. The suckers were strong, 0.296 mm in diameter, the muscular wall 0.064 mm thick; cavity of the sucker round; the opening somewhat oblong and directed diagonally toward the front. The constriction (0.7 mm from the anterior extremity) is 0.664 mm broad. Then follows an unsegmented portion (neck) 0.8 mm long, at the end of which the first signs of strobilization are visible. In some specimens the neck appears short and thick, in others very long and thin (contraction). In the neck two longitudinal canals are visible on each side.

In the examination of preserved material too much confidence must not be laid upon the size of the head, as it may contract or shrink in preparation. Press preparations also give more or less artificial pictures. Thus the following measurements were found in preserved material and balsam preparations:

Diameter of head.	Posterior edge of plane from anterior point.	Diameter of suckers.	Muscular wall of suckers.	Distance of constriction from anterior extremity.	Diameter of constriction back of the head.	Strobilization begins back of constriction.
mm.	mm.	mm.	mm.	mm.	mm.	mm.
1.. 0.40	0.528	0.30	0.072	0.8	0.312	0.8
2.. 0.548	0.326	0.288	.....	0.480	0.252	0.64
3.. 0.448	.....	0.192	0.072	0.4	0.216	0.8
4.. 0.67	.....	0.256	0.064	0.56	0.496	1.48

Most of these variations are due to contraction. The head of fresh specimens generally measures 0.7–0.9^{mm}. The segments are at first extremely short and indistinct, but they rapidly become much broader, longer, and sharper in their outline. Seven to 12^{mm} from the head (segment *ca.* 150) the segments measure 0.062–0.112^{mm} long by 1.5–2^{mm} broad; they are very thin. At this point (Plate I, Fig. 3) we find the first trace of genital organs in the form of round clumps of tissue, 48 μ in diameter, in the lateral portion of the median field (just inside the longitudinal canals); two anlagen* are present in each segment.

Segments 70^{mm} from the head measure 4^{mm} broad by 0.3–0.55^{mm} long (Plate I, Fig. 4). The genital pores have not yet pierced the edge of the segment. The anlagen of the genital canals are still solid and extend from the lateral margin of the anterior half, a distance of about 0.3^{mm} towards the median field, crossing the longitudinal canals and ending in a double knob. The anterior portion of the knob belongs to the male genitalia, the posterior to the female genitalia. No testicles are visible.

The distal border of every segment is very slightly wavy and overlaps the proximal border of the next following segment about 0.032^{mm}. The juncture of the segments is differentiated in the median field to the extent of showing a linear group of cells each side of the median line; this organ will be described more fully below.

The longitudinal canals, which were of nearly the same diameter in the head, have changed in position and size. The ventral canal has a lumen of about 0.1^{mm}, and is nearer the margin of the segment; the dorsal canal is but 0.05^{mm} broad, and lies on the median side of the ventral canal, at the same time slightly dorsal of the latter.

The testicles first appear in segments about 100^{mm} from the head. At first they are arranged in two triangles pointing towards the median line, as in *M. trigonophora* (see p. 38), but they very soon lose this arrangement (see below).

Segments 14^{cm} from the head measure 8^{mm} broad and 0.4^{mm} long. The genital pore is distinct and the male and female canals are very plain. The genital pore is in the anterior half of the edge of the segment. The vas deferens is very slightly convoluted; the testicles have increased in number and they are nearly as numerous in the median as in the submedian fields. None were found in the lateral fields.

Of the female organs one can distinguish vagina, receptaculum seminis, shell-gland, vitellogene gland, ovary, and several small canals which will be considered below. The uteri are not visible. In the

*The word "anlage"—plural "anlagen"—is now being adopted by a number of American zoölogists to signify the *incipient rudiment* of an organ. This is the meaning given to the word in this paper. Prof. E. L. Mark has recently introduced the term "fundament" as equivalent to the German "Anlage."

median field each segment overlaps the one next following by 0.176^{mm} ; and at the juncture of every two segments there is a differentiation in the median field (about 0.68^{mm} each side of the median line) which colors very dark in acid carmine. Sacs such as we find in *M. expansa* (see p. 32) are, however, nowhere developed. The arrangement of the various organs can be especially well seen in segments 180–400 $^{\text{mm}}$ from the head, measuring 9–13.5 $^{\text{mm}}$ in breadth by 0.67 – 0.96^{mm} long by 0.17 – 0.26^{mm} thick.

The segments are quadrate in form (Plate II, Fig. 4). The posterior flap of each segment overlaps the anterior portion of the next following segment by 0.192^{mm} (Plate I, Fig. 5). The first thing which strikes the eye on the stained specimen is the deeply colored line at the juncture of the segments, running parallel to the posterior edge and measuring about 1.9 $^{\text{mm}}$ long by $48\ \mu$ wide. Upon examining this in sections with a high power it is found to be distinctly cellular in structure. On frontal sections (Plate II, Fig. 2) the cells are arranged irregularly in groups. This grouping is more or less artificial, and caused by the longitudinal muscles. The cells are drawn out at one end, which inclines toward the nearest muscle-fiber. The round nuclei ($4\ \mu$) are very distinct and the nucleolus ($2\ \mu$) is very sharply defined. Generally only one dark spot is found in the nucleus, but occasionally two are found. In Plate III, Fig. 2, it will be seen that these cells surround the border between two succeeding segments, and that they are directed towards the cuticle. They have the same appearance as the cells surrounding the interproglottidal sacs in *M. expansa*, and probably represent a low stage in the phylogenetic development of those organs. The grouping which, as stated, is in this case irregular and apparently dependent on the position of the longitudinal muscle fibers, reaches its highest development around the sacs in the species of the *Expansa* group.

The genital pores are in the lateral margin, invariably in the anterior half of the segment (Plate II, Fig. 4, and Plate III, Fig. 3). The male and female openings present the following constant topographical relations: On the right hand side of the segment the vagina is ventral, while the cirrus lies dorsal in the same transverse plane; on the left side the position is reversed so that the vagina is dorsal and the cirrus is ventral in the same transverse plane (Plate II, Fig. 3, 4). This arrangement was found constant in every segment examined.

The vagina leads toward the female glands, which lie just median of the longitudinal canals, while the vas deferens extends from the cirrus across (dorsally) the female glands to the testicles, which are scattered throughout the median field (Plate II, Fig. 4).

Male genitalia.—The cirrus-pouch extends straight towards the median line of the body. It is 0.28^{mm} long, 0.096^{mm} in diameter (Plate II, Figs. 3, 4, and Plate III, Fig. 4). The inverted cirrus runs through its center, forming but comparatively few convolutions. The layers of the cirrus-pouch, beginning at the center, are as follows: (1)

lumen; (2) ciliary projections extending into the lumen. Zschokke states that this is of cellular nature in *Tenia expansa*, but we were unable to convince ourselves of the correctness of this statement as applied to *M. planissima*. We saw in sections a number of nuclei which were apparently in this layer (Plate III, Fig. 4) but, which upon further study proved to be in the next following layer; (3) a more or less homogenous layer containing numerous nuclei, hence of cellular origin. In (Plate III, Fig. 4) some of these nuclei appear as if they were in layer 2, but the circular muscles prove that the section was not exactly straight; 2 and 3 are probably to be looked upon as a single layer, or more strictly speaking, as arising from a single layer of cells; (4) circular muscles; (5) longitudinal muscles, *i. e.*, longitudinal in reference to the shape of the cirrus-pouch, not in reference to the worm; (6) cellular parenchyma with large nuclei; (7) circular muscles with nuclei which stain very dark. This layer is much thicker in the proximal than in the distal portion of the pouch; (8) longitudinal muscles.

For the study of layers 7 and 8 this species is not very good. In cross sections of the pouch the circular muscles (Plate III, Fig. 6) are very evident, but it is only with the greatest difficulty that the longitudinal fibers are seen, while in longitudinal sections the reverse is the case, except that the circular fibers of the proximal portion come plainly into view.

Upon emerging from the median end of the cirrus-pouch the male canal immediately increases in diameter, forms a number of convolutions, and crosses into the median field on the *dorsal* side of the longitudinal canals; most of the convolutions lie anterior to the vagina. Arriving at the ovary it decreases in diameter and crosses the latter dorsally.

Testicles.—At this stage there are 400 to 600 testicles scattered through the entire median field, forming a more or less regular quadrangle. There is generally no portion in the median line where the testicles are absent, such as is seen in *M. trigonophora*. On cross section they are seen to lie in the center portion of the segment, *i. e.*, between the transverse muscles.

Female genitalia.—In a depression directly dorsal (left side, ventral right side) of the cirrus lies the vulva (Plate II, Fig. 3), from which the vagina runs almost straight toward the median field of the segment. The layers of the vagina (Plate III, Figs. 4, 5) correspond very nearly to those of the cirrus, *i. e.* (1) lumen; (2) ciliary projections; (3) homogenous layer with nuclei; (4) longitudinal fibers (almost imperceptible); (5) circular fibers, which are extremely thin except at the beginning of the vagina, where they form a strong sphincter capable of completely closing the entrance; and (6) a distinct cellular layer similar to that recognized by Zschokke in *T. expansa*.

It will be noticed that in the cirrus the circular muscles (4) are surrounded by the longitudinal fibers (5), while in the vagina the reverse is

the case. This has already been noticed by other authors, Zschokke for instance, in other species (*T. expansa*).

The vagina runs toward the median field and passes the longitudinal canals on their dorsal side, retaining a nearly uniform diameter for about 0.72 mm . Then it suddenly enlarges (Plate III, Fig. 3) into a short bulb, which is followed by a constricted portion $24\ \mu$ long. The latter then empties into the receptaculum seminis, which measures 0.44 mm long by 0.096 mm in diameter and lies on the dorsal side of the ovary. The histology of the receptaculum seminis is entirely different from that of the vagina, there being an inner epithelium with an outer basement membrane. From this point the topography of the canals can be made out only by a patient study of numerous sections. Our studies on sections in the three directions have led us to the following results (Plate II, Fig. 1 and Plate III, Figs. 1-3):

From the ventral side of the receptaculum seminis, a short distance from its median extremity, a canal takes its origin; this canal runs about 0.132 mm in a curved direction, the convexity being ventrad and slightly distal; it is made up of a high interior epithelium (nuclei $3\ \mu$) with a basement membrane. This canal (oviduct) in which, as we shall see later, the ova come in contact with the spermatozoa (hence "fertilization canal"), leads from the ovary, from which it is separated by a short constriction provided with circular fibers. Thirty-two μ from the origin of the above-described canal another canal branches off from it dorsally, makes one or more convolutions, and enters the shell gland; in about the center of the latter it divides into two canals, one of which passes straight through the gland in a ventro-distal direction and dilates suddenly into the calyx of the vitellogene gland. This latter canal is the vitello-duct. The other canal runs from the center of the gland dorso-anteriorly, makes several convolutions both in the shell-gland and after it leaves it, then runs to the uterus. The relations of these canals are given in Plate II, Fig. 1, and Plate III, Fig. 1, which are slightly diagrammatic.

Ovary.—The ovary is nearly renal in form, varying slightly according to the contraction of the segment (Plate III, Fig. 3). When the segments are expanded, the ovary, shell-gland, and vitellogene gland together form a circular body, but when the segment is more or less contracted, this circular body becomes lengthened in its lateral diameter and shortened in its longitudinal diameter. The ovary in Plate III, Fig. 3, measures 1.12 mm in its lateral diameter. Coloring liquids differentiate the organ into two distinct parts; a peripheral portion (cortex) which stains very dark and represents the ovarian tubes, and a central portion (calyx) which stains more lightly. All the tubes lead into this central portion from which the oviduct runs.

The vitellogene gland (Plate II, Fig. 1, and Plate III, Figs. 1-3) lies on the posterior (distal) side of the ovary, and is nearly inclosed by the projecting sides of the latter. It measures 0.4 mm by 0.24 mm . In preparations

this organ appears much darker than the ovary, owing to the fact that the nuclei are of a darker color, slightly smaller, and more crowded. The gland is composed of tubes which lead into a common calyx from which the vitello-duct takes its origin. While the ovary consists of long, thin tubes, the vitellogene gland is more acinus-like in its character.

Shell-gland (Plate II, Fig. 1, and Plate III, Figs. 1-3).—Between the ovary and vitellogene gland, and on the dorsal side of the latter, is situated an irregularly shaped organ which is known as the shell-gland. The point where the vitello-duct and oviduct come together (oötyp) forms approximately the center of the gland. The nuclei of the gland (5μ) are very similar to those of the ovary, and take on about the same stain.

Uterus.—No connection can be traced between the uteri-anlagen of the two sides of the segment, hence we have originally (ontogenetically) two uteri, corresponding to the two sets of organs.

Excretory canals.—The ventral longitudinal canal lies laterally of the dorsal canal and slightly ventrally. Its lumen is flattened dorso-ventrally (0.2mm by 0.016mm) and is extremely irregular; its cuticular lining is very thin. In the posterior portion of each segment it is connected with the corresponding canal of the other side by the transverse canal. The dorsal canal is smaller (0.064mm by 0.008mm); the cuticular lining is thicker than that of the ventral canal. Cells are grouped more or less regularly around the dorsal canal, but we can hardly look upon them as forming a distinct epithelium such as Zschokke described in his article on *T. expansa*.

The longitudinal nerves can be distinguished on the lateral side of the lacunes. They cross the genital canals ventrally. From this point to the end of the strobila the segments continue to increase considerably in breadth but very slightly in length. Segments 60cm from the head measured 14mm by 1mm ; 80cm from the head, 16mm by 1mm ; 1m from the head, 18mm by 1.5mm , and 1.25m from the head, 20mm by 1.75mm . In one worm segments 26mm broad were found. The last few segments show a disposition to become slightly longer and narrower.

As the uteri increase in size they make numerous folds which completely fill up the median field and extend into the lateral fields, crossing the longitudinal canals dorsally. In the median line the two uteri come together in such a way that it is impossible to distinguish one from the other (Plate II, Fig. 5).

In the meantime the other genital organs atrophy, the testicles being the first to disappear; then the ovary, vitellogene gland, and shell-gland fade; the receptaculum seminis, vagina, and cirrus-pouch persist the longest (Plate II, Fig. 5).

Eggs.—The ova are more or less globular, measuring 63μ in diameter; by reciprocal pressure they become cuboid. The embryo, which measures $16\text{--}18\mu$ in diameter and is provided with the six characteristic hooks 9μ long, is surrounded by a pyriform apparatus. The bulb

of the apparatus—*i. e.*, that part directly surrounding the embryo—measures 20μ in diameter. The horns are 24μ long, appear to be hollow, and end in a disk 15μ in diameter. When viewed *en face* the disk is nearly round. In the center are seen the ends of the two horns, each 3μ in diameter, and several—generally four—round nuclear bodies (3μ), each containing one or two very refringent dots. These four bodies have every appearance of being true nuclei. When treated with caustic soda the disk frequently assumed the fringed appearance which Curtice figures in *Tænia expansa*.

There is a thin membrane inside the bulb of the pyriform apparatus, and at a point near the horns this membrane was invaginated toward the embryo (Plate II, Fig. 6). This observation was made upon preserved material, so that it is not impossible that this is to be explained by a contraction of the embryo. The horns are surrounded by a granular fatty substance.

SPECIFIC DIAGNOSIS.

From the above anatomical description we feel justified in giving the following specific diagnosis:

Moniezia planissima S. & H., 1892.—Adult strobila 1 to 2^m long; yellowish. Head quadrate, 0.4–0.9^{mm} broad; suckers at the four corners and directed forwards (diameter 0.25^{mm}); dorsal and ventral surfaces usually show a distinct plane running across the suckers and ending about 0.5^{mm} from the anterior extremity (balsam preparations). Neck broad, 0.6–1.5^{mm} long or very narrow and long. First traces of genital organs 7–12^{mm} from the head (segment *ca.* 150). The segments are at first extremely short; always much broader than long and longer than thick; ripe segments 12–26^{mm} broad by 1–1.75^{mm} long, generally thin. Interproglottidal glands linear, large and very distinct. Genital pores double, situated in the anterior portion of the lateral margin; vagina and cirrus on the same transverse plane—on the right, vagina ventral, cirrus dorsal; left side vagina dorsal, cirrus ventral; genital canals pass dorsally of the longitudinal canals and nerves. Testicles begin about 10^{cm} from the head, at first arranged in two triangles; 400–600 testicles present in ripe segments and generally as numerous in the median line as elsewhere, so that the testicles of each side cannot always be distinctly separated. Uterine folds enter the lateral fields. Eggs 63μ in diameter; bulb of pyriform apparatus 20μ ; horns 24μ ; embryo 16–18 μ ; hooks 9μ . (See also generic diagnosis, p. 54).

Type specimen is in the Bureau of Animal Industry; typical specimens will be sent to museums and specialists exchanging with this Bureau.

S. & H.

(2) *Moniezia Benedeni* (Moniez, 1879) R. Bl., 1891.

[Plate II, Figs. 7, 8.]

Synonymy.—*Tænia Benedeni* Moniez, 1879; *Moniezia Benedeni* (M.) R. Bl., 1891; *Tænia denticulata* Neumann, 1892 (fig. of scolex.)

Hosts.—Domestic sheep (*Ovis aries*), Moniez; cattle (*Bos taurus*), Moniez, v. Marenzeller.

Geographical distribution.—France (at Lille, Moniez); Austria (at Vienna, v. Marenzeller).

LITERATURE.

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- (2) RAILLIET, A. Éléments de Zoologie Médicale et Agricole, 1886, p. 261, *Tænia Benedeni*.
- (3) NEUMANN, L. G. Traité des Maladies parasitaires non-microbiennes des animaux domestiques, 1st ed., 1888, p. 383, *Tænia Benedeni*.
- (4) BLANCHARD, R. Sur les Helminthes des Primates anthropoïdes; Mém. d. l. Soc. Zool. d. France, 1891, p. 187, footnote, *Moniezia Benedeni*.
- (5) MONIEZ, R. Notes sur les Helminthes. VI, 1; Revue Biologique du Nord d. l. France, 1891 (Extr. pp. 14-16), *Moniezia Benedeni*.
- (6) BLANCHARD, R. Notices helminthologiques. 2. sér., 7; Mém. d. l. Soc. Zool. d. France, 1891, p. 444, *M. Benedeni*.
- (7) NEUMANN. Traité, etc., 2 ed., 1892, p. 408, *T. Benedeni*.—Engl. Transl., p. 418, *T. Benedeni*.

HISTORICAL REVIEW.

This species was first described by Moniez (1) as a worm of 4^m or more long; head large in proportion to the neck; last segments more than a centimeter broad; longitudinal muscles of one surface developed more than those of the other surface. The parasites were found in the intestine of sheep at Lille, France. The above diagnosis is also given by Railliet (2). Neumann (3) adds that the head is small, globular, and followed by a filiform portion 4-5^{mm} long, in which the segments are visible; the eggs are 75-80 μ , and show a pyriform apparatus. R. Blanchard (4) then states in a footnote that he includes this species in his new genus *Moniezia*. This publication was immediately followed by one from Moniez (5), in which he accepts Blanchard's classification and adds the following in regard to *M. Benedeni*: "The worm is remarkable on account of the thickness and breadth of the segments; in contraction the latter attain 12^{mm} in breadth, 3^{mm} in length, and 2^{mm} or more in thickness; the head is more than 1^{mm} thick; the suckers are strong, prominent, 0.45^{mm} in diameter, and touch each other; same form found in seven individuals; neck 2.5^{mm} long; form of segments the same through entire length; found in cattle as well as sheep. Ova 80-85 μ , pyriform apparatus 18 μ , embryo 15 μ ." In Blanchard's second publication (6) the worm is simply mentioned as belonging to the genus *Moniezia*. In the second edition of Neumann's work (7) the specific diagnosis is not enlarged, but a figure is given of a head of the worm which the author considers to be *T. Benedeni*. In response to a request both Moniez and Neumann kindly forwarded specimens which they included in this species. Neumann's specimen, however, agrees perfectly with *Moniezia trigonophora*.

Moniez's specimen bears the label "Mouton 31 (? indistinct—c. w. s.), 79, i, prep. xx. le 2 gros. fragm.=? du même." As he described this parasite in 1879, and as he was asked for his original type, it is assumed that the "79" refers to the year, and that the sample sent is some of his original material; this specimen forms the basis of the

present description. Moniez's interrogation point on the label signified that he suspected there was more than one species contained in the bottle. His suspicions proved to be perfectly correct, for besides the *M. Benedeni*, which was easily recognized from his description of the head, segments of *M. expansa* and *Th. Giardi* were found. A tapeworm labeled "*T. expansa*" was received from Dr. von Marenzeller, of Vienna, which agrees with Moniez's type of *M. Benedeni*.

ANATOMY.

External appearance.—Plate II, Fig. 7, represents a strobila (natural size) which was received from Moniez. The animal is considerably contracted. It will be noticed that the head is quite large, the neck is quite stout, the segments are distinct, thick and much broader than long. Fig. 7a gives two enlarged segments, which show a peculiar checkered appearance of the cuticle; this is common to all the large segments. The strobila is very opaque.

Scolex.—Figs. 8, 8a agree perfectly with Moniez's description (5) of the head. Upon comparing these figures with Neumann's figure of the scolex of *T. denticulata* (7, Fig. 183), it will be noticed that they are almost identical. Prof. Neumann was kind enough to send 4 strobilae of the worm which he looked upon as *T. Benedeni*, and they do not agree with Moniez's type, but, as stated above, with *Moniezia trigonophora*, so that we are forced to assume that Neumann's diagnosis of *M. Benedeni* must be dropped, and that his *T. denticulata* (partim) is probably identical with Moniez's *M. Benedeni*.

The head of Moniez's *M. Benedeni*, in the possession of the writer, is square, 0.96^{mm} by 0.96^{mm} ; length 0.48^{mm} . Two furrows cross the anterior surface of the head and extend around on the four sides; these furrows are connected by furrows posterior to the suckers, thus separating the latter from the strobila. This arrangement of furrows gives the head a lobed appearance, each of the 4 lobes representing a large sucker 0.48^{mm} in diameter; the opening of the suckers must of course vary with the state of contraction. In Figs. 8, 8a the opening is small and circular. The specimen of this species is so contracted that it would be altogether too hazardous to make many statements in regard to its internal anatomy. It can, however, be stated that the interproglottidal glands are *extremely indistinct* (absent?), without sacs, but *appear* to be linear, as in *M. planissima*. There appears to be no reason, however, for uniting these two species, since the heads and strobilae are so totally different. Furthermore, Moniez states that the contracted segments measure 12^{mm} broad by 3^{mm} long by 2^{mm} thick, which measurements do not agree with those of *M. planissima*. The general topographical relations of the vagina, cirrus, genital canals, genital glands, longitudinal canals and nerves are the same in this species as in *M. planissima*; the arrangement of the testes, however, was not observed.

Ova.—As stated above, Moniez gives the measurement of the ova as $80-85 \mu$, of the embryo 15μ .

SPECIFIC DIAGNOSIS.

From our present knowledge of this parasite we may accept the following as a provisional diagnosis:

Moniezia Benedeni (Moniez, 1879) R. Bl., 1891.—Strobila attains a length of 4^m; head 1^{mm} or more large; obtuse, 4-lobed, suckers directed diagonally forwards, opening circular. Neck present, slightly narrower than the head, about 2-2.5^{mm} long. Segments always broader than long; contracted ripe segments attain the measurement of 12^{mm} broad by 3^{mm} long by 2^{mm} thick. Topography of longitudinal canals, genital canals, and female glands the same as in *M. planissima*; testicles? Interproglottidal glands *extremely indistinct* [absent?], without sacs. Ova 80-85 μ in diameter; embryo 15 μ ; pyriform apparatus 18 μ .

Type specimens are in the possession of Prof. Moniez, Lille, France, and C. W. Stiles, Washington, D. C. One very typical specimen is in the K. K. Museum in Vienna, Austria.

C. W. S.

(3) *Moniezia Neumanni* Moniez, 1891.

[Plate IV, Figs. 1-5.]

Host.—Sheep (Moniez).

Geographical distribution.—France (Lille, by Moniez).

LITERATURE.

- (1) MONIEZ, R. Notes sur les Helminthes, vi, 2; Revue Biologique du Nord de la France, 1891, t. iv, 1 page.

HISTORICAL REVIEW.

Moniez gave a very short description of this worm (1), by which it has not been possible to recognize the species. He was, however, so kind as to send specimens. He states (1) that the head has the same dimensions as that of *M. Benedeni*, and is more than 1^{mm} in diameter; suckers agree with those of *M. Benedeni*; while the neck is the same length as in *M. Benedeni* but filiform. The strobila is much shorter (1-2 feet); segments narrower (8^{mm}), thinner, and 1-1.5^{mm} long; the segments which are about to become detached are 6 by 2^{mm}. Ova measure 55-56 μ , embryo 18-21 μ .

ANATOMY.

Only contracted segments (Plate IV, Fig. 1) are at hand, and but little in regard to the anatomy of this species can be given.

Scolex.—The head resembles that of *M. Benedeni* in some respects; it is almost square when viewed *en face* (Plate IV, Fig. 2a), 0.9^{mm} broad; when viewed from the dorsal or ventral surface, the suckers do not appear so distinctly separated from the neck. The openings of the suckers are quite small, situated at the four corners and directed diagonally forward. The segments are all broader than long.

In several segments measuring 1.2^{mm} wide by 0.56^{mm} long (Plate IV, Figs. 3, 4), the genital pore was just on the point of piercing the lat-

eral margin of the segment in its anterior third. The male and female canals were distinct from each other, but their lumina were very indistinct. The female glands were very small, but could be distinguished. A large number of testicles were distributed in the median field, and they were as numerous in the median line as elsewhere. Short linear interproglottidal glands without sacs were present in the median line. In several segments (Plate IV, Fig. 5) measuring 4^{mm} wide by 2.2^{mm} long, the uteri occupied almost the entire segment and were filled with ova. The other organs were atrophied. The genital pore was in the middle or anterior half of the segment. In the segments 6.5^{mm} wide no details were recognized.

SPECIFIC DIAGNOSIS.

The specific diagnosis of this cestode is very unsatisfactory, owing to our lack of knowledge in regard to important details.

M. Neumanni M., 1891.—Strobila 1½ to 2 feet long, perhaps longer. Head square, 0.9^{mm} or more broad, suckers powerful, same diameter as in *M. Benedeni*, but not so distinctly lobed as in that species. Neck about 2-2.5^{mm} long, anterior portion filiform, very thin. Segments narrower and thinner than those of *M. Benedeni*; the largest segments measure 8^{mm} broad by 1.5^{mm} long; the segments at the posterior end somewhat narrower and longer, 6^{mm} by 2^{mm}. Topography of longitudinal canals, genital canals, and female glands probably the same as in *M. Benedeni*; testicles arranged in a quadrangle. Interproglottidal glands small, linear, without sacs. Ova 55-65 μ ; embryo 18-21 μ .

Type specimens are in the possession of Prof. Moniez, Lille, France, Bureau of Animal Industry, and C. W. Stiles, Washington, D. C.

It will be seen from the above that *M. Neumanni* as well as *M. Benedeni* must be subjected to a thorough anatomical study by some one who can obtain the proper material. The powerful contraction of the specimens, and the inability to obtain fresh material, is offered as an apology for not going more into details. See also *M. nullicollis* (p. 83).

C. W. S.

B. *Expansa* Group. (*M. expansa*, *M. oblongiceps*, and *M. trigonophora*.)

Characterized by the grouping of the interproglottidal glands around blind sacs.

(4) *Moniezia expansa* (R., 1810) R. Bl., 1891.

[Plate V, Figs. 1-3; Plate VI.]

Synonymy.—(After Rudolphi) *Tenia evis nutritiis distinctis* Bloch, 1782; *T. ovina* Goeze, 1782; *T. ovina* Batsch, 1786; *T. ovina* Schrank, 1788; *T. ovina* Gmelin, 1789; *Halysis ovina* Zeder, 1803—(After Creplin) *T. denticulata* Mayer—(After Baird, 1853) *Atylsemithus expansus* Blainville—(After Stiles) *T. expansa*, ex parte of Railliet, Neumann, Perroncito, Curtice, and other recent authors.

Hosts.—Sheep (*Ovis aries*), found by various authors; cattle (*Bos taurus*), found by various authors; Zebu (*Bos indicus*), found by Perroncito; goats (*Capra hircus*); Pyrenian tor or ibex (*Capra pyrenaica*); roe deer (*Capreolus caprea*), reported by Nitzsch; pampas deer (*Cariacus campestris*), see Dies.; brocket (*Cariacus rufus*), see Dies.; *Cervus Nambi*, see Dies. (collected by Natterer); *Gazella dorcas*, reported by Bremser, see Dies.; *Ovis moschatus*; gemse or chamois (*Rupicapra tragus*), reported by Bremser.

Geographical distribution.—North America: Chicago, Ill., *Stiles; Washington, D. C., *Curtice, *Hassall, *Stiles; Colorado, Curtice. South America (Brazil, Natterer). Europe: England, Hassall and others; France, *Railliet, *R. Blanchard, Neumann, Moniez, *Stiles, and others; Germany and Austria, Leuckart, Bloch, Göze, Nitzsch, *Rudolphi, *Zschokke, *Stiles, and many others; Italy, Perroncito and others.

Besides the above, this species is mentioned by numerous other authors in various parts of the world. In all probability some of the cases are those of true *M. expansa*, while in other cases the data given are too incomplete to determine whether the species found was *M. expansa* or some other form. An examination has been made of the specimens of this species collected by those men whose names are starred (*) in the above list. It is very certain that many of the cases of *Tania expansa* reported in America are either *Th. actinioides*, *M. planissima*, or *M. trigonophora*. In all probability this is the most widely distributed species found in cattle and sheep (See extract from letter by Dr. Giles, p. 74.)

LITERATURE (1810-1892).

- (1) RUDOLPH. Ent. Hist. nat., ii, 2, 1810, p. 77-79, *Tania expansa*.
- (2) ——— Ent. Syn., 1819, pp. 144, 487.
- (3.) GURLT. Lehrbuch der pathologischen Anatomie der Haussäugethiere, 1831, i, p. 381, x, 1-2.
- (4) ——— Hartwig's Mag. d. Thierheilkunde, iv Jahrg., 2. Heft.
- (5) MAYER. Friep's Neue Notizen i, p. 107 (*T. denticulata*)
- (6) ———. Analecta f. vergl. Anat. 2. Samml. i, p. 70, figs. 4-5. Review by v. Siebold in Wiegmann's Arch. f. Naturg. 1840, ii, p. 192.
- (7) CREPLIN. Endozoologische Beiträge. 1 Ueber *Tania denticulata* Rud. und *Tania expansa* Rud.; Wiegmann's Arch. f. Naturgeschichte, 1842, i, pp. 315-327.
- (8) DEJARDIN. Hist. nat., p. 577.
- (9) DIESING. Syst. Helm., i, p. 497.
- (10) VERRILL, A. E. Parasites of domestic animals; Report of the Connecticut Board of Agriculture for 1870, pp. 65, 100.
- (11) DAVANE. Traité des Entozoaires, 1877, p. liii, 235.
- (12) MONIEZ. Mémoires sur les Cestodes. Paris, 1881, pp. 15-21, pl. i, figs. 38-58, ii, 1. (Embryology.)
- (13) ZERN. Die th. Parasiten, 1882, p. 189-192, taf. iii, figs. 39-41.
- (14) PERRONCITO. I Parassiti, etc., 1882, p. 239, figs. 99-100.
- (15) ———. Trattato sulle Malattie degli Animali domestici, 1886, pp. 231-232, 233.
- (16) McMURRICH. Ninth Annual (1883) Report of the Ontario School of Agriculture (1884), pp. 174-178, 7 figs. (Zoological Report.); F. G. GRENSIDE, same Report, pp. 200-203. (Veterinary Report). (Rev. by v. Linstow, Arch. f. Naturg., 1888.) [*T. expansa*=*M. trigonophora*, vide p. 37.]
- (17) LEUCKART, R. Bandwürmer; Koch's Encyclopädie der gesammten Thierheilkunde, 1885, pp. 396-399; *T. expansa*, under *Dipylidium*.
- (18) RAILLIET. Éléments, etc., 1886, p. 257-260, fig. 151 (orig.), fig. 152 (after Neumann), fig. 153, 1-12 (after Moniez).
- (19) NEUMANN. Traité, etc., 1st ed., 1888, p. 377-378; figs. 164 (1-12) (after Moniez), 165 (after Railliet), 166 (orig.).
- (20) CURTICK, C. Animal Parasites of Sheep, 1890, pp. 113-122, pls. xiv, xv.
- (21) ZSCHOKKE. Recherch sur la structure anatomique et histologique des Cestodes, 1890, pp. 91-114, taf. ii-iii, figs. 31-38.
- (22) BLANCHARD, R. Sur les Helm. des Anthro. (Footnote); Mém. d. l. Soc. Zool. d. France, 1891, p. 187. (*Moniezia expansa*.)
- (23) MONIEZ. Notes sur les Helm., vi, 4; Rev. biol. du Nord de la France, 1891,

- (24) BLANCHARD, R. Notices Helm., 2 sér., 6; Mém. d. l. Soc. Zool. de France, 1891, p. 445.
- (25) NEUMANN. Traité, etc., 2nd ed., 1892, p. 402, 407; figs. 184-186.—Engl. Transl., 1892, pp. 412, 418, 429. (*T. expansa*.)
- (26) DEWITZ. Eingeweidewürmer der Haussäugethiere. Berlin, 1892, p. 77-81, figs. 51-52.
- (27) STILES. Notes sur les Parasites—14: Sur le *Tenia expansa* Rud.; Compt. rend. d. l. Soc. d. Biol. (Paris) 1892, p. 664.
- (28) ———. Bemerkungen über Parasiten—17: Ueber die topographische Anatomie des Gefässsystems in der Familie *Teniadae*; Centralblatt f. Bakteriologie und Parasitenkunde, 1893, bd. xiii, p. 457-465, figs. 1, 2. (*M. expansa*.)

HISTORICAL REVIEW.

It is almost impossible to give a satisfactory historical review of this species, since very few of the diagnoses given by authors can be applied to this worm alone.

Rudolphi (1) starts off his description of the species with the diagnosis—

"*Tenia expansa* R.—Capite obtuso, collo nullo, articulis anticis brevissimis, reliquis subquadratis, foraminibus marginalibus oppositis."

As synonyms and literature he gives:

Bloch.—Abhandlung von der Erzeugung der Eigeweidewürmer und den Mitteln wider dieselben. Berlin, 1782, 4^o 10 Taf., p. 16, Taf. 5, figs. 1-5. *Tenia vasis nutritiis distinctis*.

Goeze.—Versuch einer Naturgeschichte der Eingeweidewürmer thierischer Körper. Leipzig, 1782, 44 Taf., p. 360-371, Taf. 28, figs. 1-12. *T. ovina*.

Batsch.—Naturgeschichte der Bandwurmattung überhaupt und ihrer Arten insbesondere, nach den neuern Beobachtungen in einem systematischen Auszuge. Halle, 1786, p. 182, n. 28, figs. 109, 162. *T. ovina*.

Schrank.—Verzeichniss der bisher hinlänglich bekannten Eingeweidewürmer, nebst einer Abhandlung über ihre Anverwandtschaften. München, 1788, 8^o, p. 38, No. 115, *T. ovina*.

Gmelin.—Linné's Systema Naturæ, 1789-1790, p. 3074, No. 55. *T. ovina*.

Tabl. Encycl. t. 45, figs. 1-12 (ic. Goeze). *T. ovina*.

Zeder.—Anleitung zur Naturgeschichte der Eingeweidewürmer. Bamberg, 1803, p. 332, n. 7. *Halysis ovina*.

Rudolphi then gives a more detailed description of the animal; but that this description is insufficient is conclusively proven by the fact that many helminthologists since Rudolphi's time have had difficulty in recognizing the proper *T. expansa*. Although Rudolphi acknowledges that his species is identical with the species *T. ovina*, he renames it *T. expansa*. There seems to be an impression among certain authors that the word *expansa* refers to the breadth of the worm, but this is not the case, for Rudolphi writes: "Ipse maximam ab agni pyloro ad cæcum usque expansam et villosæ adhærentem vidi, unde nomen triviale desumsi." Hence Rudolphi referred to the length rather than the breadth in using the term *expansa*.

As far as the literature and synonyms which Rudolphi gives are concerned, the following have been found:

In the French edition of Bloch's work (p. 35-37, v. 1-5) a worm is described which may or may not be considered identical with Rudolphi's

T. expansa. In the former the head is large, and the genital pores, in nearly every segment figured, are exactly in the middle of the margin. The shape of the head is quite similar to that of *expansa*. In *expansa* the head is small, the pores generally in front of the middle of the edge. The worm Goeze describes as *Tania ovina* could, with a little imagination, be called identical with Rudolphi's *expansa*.

The articles by Batsch and Schrank are not at hand. Gmelin evidently takes his diagnosis from Bloch's article. The other two books are not to be obtained here.

Rudolphi is probably as far back as it is possible to trace *T. expansa* with certainty. Having in my possession part of his type material I feel obliged to accept his name *expansa* in preference to the name *ovina*, which antedates it. If, however, the original material of Goeze can be examined, and if by that means it can be demonstrated that *ovina* is really identical with *expansa*, then I should be in favor of holding to the law of priority and of vindicating Goeze even at this late date. As Rudolphi himself believed his species to be identical with Goeze's *ovina*, he had no excuse for renaming the species.

In his synopsis Rudolphi (2) adds nothing of any importance in regard to *T. expansa*.

Gurtl (3) gives a short description of *T. expansa*, together with two figures. It is probable that this is really *T. expansa*, although it may possibly belong to some other species. It has not been possible to obtain Gurtl's second article.

Mayer (5-6) speaks of *T. denticulata* in two articles (see below).

Creplin (7) gives quite a good discussion of the differences between *T. expansa* and *T. denticulata*. His diagnosis for *T. expansa* reads:

T. capitis parvi oblongi, antice et lateribus rotundati, retrorsum angustati osculis perfecte lateralibus, magnis, tumidis, collo cum corpore toto plano, subtili, cum capite, se crassiore, continuo, perbrevis, articulis primis brevissimis, marginibus lateralibus convexiusculis, sequentibus lentissime latescentibus elongatisque et simul marginibus lateralibus rectioribus demumque fere prorsus rectis, postico recto, saepe crispato, semper tumidulo, uti angulis obtusis, perparum prominentibus, articulis ultimis solis, cum se antecedentibus sensim angustioribus factis, primo quadratis, tum (perpaucis, neque semper), adeo longioribus quam latioribus, terminali obtuse finito, osculis genitalibus marginalibus plures pollices a capite monstrari incipientibus, tum ad caudam usque, secundis oppositis. (Ova globiformia et angulata.)

Creplin evidently had the true *T. expansa* before him, although it is not impossible that he also had some other species. He says that Mayer's (6) *denticulata* is really *expansa*. He thinks also that Carlisle's specimens were *expansa*.

Dujardin (8) does not add anything new to our knowledge of *T. expansa*. His "large de 5-27 mm; ventouses dirigées en avant" seems to indicate that more than one species is included in the diagnosis.

Diesing (9) gives a short Latin diagnosis of the species.

Verrill (10) evidently has several species included in his diagnosis of *T. expansa*.*

Davaine's diagnosis (11) is short. He also gives a short account of symptoms and treatment of animals affected by the parasite.

In Moniez's Mémoires sur les Cestodes we find an account of the embryology of tapeworms of the type *Tania expansa*. His results are as follows:

The ovum of *T. expansa* first appears as a small cell filled with yolk and provided with a body which seems like an excentric nucleus; this latter, however, is the true ovum. A vitelline membrane appears after fecundation, and the ovum divides; one of the resulting bodies separates from the vitelline matter and multiplies rapidly, forming the blastodermic cells; the other cell remains included in the vitelline matter and becomes very refringent (polar body). The blastodermic cells increase in number, forming a morula, while the vitelline matter contains the polar body. The vitelline matter divides into two semilunar bodies which surround the morula, and each of which contains a large vitreous cell. The morula now gives off in succession two concentric cellular layers; the cells of the outer layer form an envelope for the embryo, then become indistinct and granular. The inner layer of cells then pushes out two horn-like prolongations on one side and forms the so-called pyriform body, inside of which lies the six-hooked embryo (oncosphere). That portion of the outside cellular layer which is included between the two horns of the pyriform apparatus, according to Moniez, forms the prominent circular or radiate body (disk) situated at the end of the horns.

Zürn (13) describes symptoms and gives treatment for animals infested with these tapeworms. His specific diagnosis is short. He goes back to the statement of earlier authors, that *T. expansa* is sometimes 60^m long. His figures are very poor. In Figure 39 part of the segments are upside down, *i. e.*, he mistakes the anterior edge for the posterior edge.

Perroncito's figures (14) are upside down. His diagnosis seems to apply pretty well to *M. expansa*, although some points in it make one suspicious of *M. planissima*. He states, contrary to Creplin, that the suckers are directed forward. The anterior portion of the strobila is described as colorless or light yellowish, while the posterior portion is a more intense yellow. The segments are said to attain a breadth of 33^{mm}.

McMurrich (16) had occasion to investigate a tapeworm epizootic among sheep in Ontario. He favors a theory that *Melophagus ovinus* (the sheep tick) acts as intermediate host for the tapeworm. Judging from his description and figures it is probable that the worm he found is the same that the writer found later (see below) in the Blairsville epizootic (*M. trigonophora*).

Leuckart (17) gives a very good general description of this parasite,

*In regard to Verrill's report, I might mention that several European authors have concluded that Verrill found in America all the species of parasites which are mentioned in that article. Prof. Verrill, however, has written to this Bureau that such was not the case. As he does not state in every case in his article which of the parasites mentioned are found in America, his report should not be used in making up the geographical distribution of the animals in question.—C. W. S.

but certain portions of his article lead me to believe that he had both *M. expansa* and *M. trigonophora* in his possession when he wrote the article. He discusses the question of life history, and suggests that some snail may possibly be the intermediate host.

Railliet (18) states that the suckers are directed forward, but gives a figure (from Neumann) in which they are directed dorso-and ventrolaterally. An original figure of an adult strobila is given, which seems to be *T. expansa*.

Neumann (19) gives substantially the same as Railliet (18).

Curtice (20) attempted to infect sheep by feeding them eggs of tape-worms. Although his results were not positive, he expresses himself as decidedly in favor of a development without any intermediate host. His experiments cannot be considered as supporting the theory.

Zschokke (21) gives an excellent account of the internal organization of *T. expansa*. There can be no doubt that he had *T. expansa* before him, for the preparations which he kindly forwarded agreed very well with Rudolphi's type specimen. Zschokke's work will be referred to hereafter in connection with the anatomical description.

R. Blanchard (22, 24) placed *T. expansa* in his new genus *Moniezia*.

Moniez (23) discusses the difference between *M. expansa* and *M. denticulata*, stating that the segments of *expansa* are thin, transparent, and yellowish.

Neumann (25) gives a new figure of the head of *T. expansa*. The figure of the head of *T. expansa* given in his first edition is now reproduced as *T. Benedeni*, but it does not agree with Moniez's original material. That Neumann, as well as Railliet, included *M. planissima* in the species *T. expansa* is already stated above.

Dewitz (26) mentions Curtice's conclusions in regard to the direct development and copies one of his figures.

Quite recently I obtained some of Rudolphi's specimens and described (27, 28) the interproglottidal sacs in them; at the same time attention was called to the fact that *M. expansa* of recent authors contained more than one species, and *M. planissima* was separated from *M. expansa*.

Above have been mentioned nearly all the articles upon *T. expansa* Rud. which it has been possible to find. The species is mentioned in several lists of parasites which are not included in this review. It is further to be expected that there are other articles upon a species so well known (by name), but that they have escaped attention.

ANATOMY.

After this tedious review of articles published on *Tania expansa*, let us pass to a description of that portion of Rudolphi's original specimen in our possession, in order to establish one of the chief points in the diagnosis of this species.

Prof. Möbius very kindly sent four portions of worms labeled "*Tania expansa*; coll., Rudolphi;" Nos. 1-3 from *Ovis aries*, No. 4 from *Gazella dorcas* (*Antelope dorcas*).

(1) Scolex very much shrunken, nearly square when viewed *en face*, 0.368 by 0.368^{mm}. The suckers occupy the four corners, are distinctly raised and directed diagonally towards the front. The openings are slit-form (Plate v, Figs. 1-1b).

(2) A strobila about 10^{cm} long by 1.5^{mm} broad. Poorly preserved. Segments are distinct (Plate v, Fig. 2). Genital organs well developed, but too indistinct to warrant description. Genital pore in anterior half of segment. Interproglottidal sacs almost imperceptible.

(3) Fifteen segments 7^{mm} broad by 1-1.3 long. Interproglottidal sacs plainly visible. The material does not warrant any other statements.

(4) (From *Gazella dorcas*.) Thirty segments; 10 (not 16^{mm} as stated in my Note 14) broad by 1^{mm} long. Somewhat better preserved than 1-3. The segments are filled with eggs; the interproglottidal sacs (Plate v, Fig. 3), are here and there visible.

From the above it will be seen that the species accepted as *Moniezia expansa* must possess interproglottidal glands grouped around sacs. The literature has been searched very carefully to find mention of these glands, but unless some statement by some author has escaped attention, the glands were first described in my preliminary note (26) before the Société de Biologie (Paris).

The question, of course, immediately arises whether these sacs can not be found in other species. As a matter of fact we find these sacs present in several species, which are included in the "*Expansa* group." By the aid of the scolex, however, we can determine which one of these is the true *M. expansa*. The scolex of Rudolphi's type agrees very well with the scolex of the worm which Curtice described as *Tania expansa*; it does not, however, agree with Zschokke's figure, although it resembles one of his preparations. The difference between this figure and Neumann's figure might, perhaps, be explained by contraction. At any rate, it is perfectly evident that Curtice's *T. expansa* comes the nearest to Rudolphi's type of any specimen in possession of this Bureau, and justifies the acceptance of that as the true *M. expansa*.

General appearance.—Specimens of this species show an extreme variation in external appearance, according to whether they are alive or fixed by different methods of preservation. These variations, however, are not more than the variations found in specimens of *Tania saginata* which have been preserved in different fluids. Older authors state that *T. expansa* grows to more than* 100 feet in length, but

* It is well known that several American physicians have reported cases of *Tania saginata* of man in which the parasites were said to be 50, 100, or even 210 feet long. Zoölogists have explained these cases by saying that the physicians had taken a number of worms, and, supposing them to be all from one individual parasite, have given the total length of all the fragments. I have myself followed this explanation in lecturing upon parasites, and believe that this is the true explanation in many, although not in all cases. Only a short time ago I called upon a physician who has several bottles in his office containing *T. saginata*, and bearing the labels "180 feet long," "185 feet long," "210 feet long," etc. Upon calling into question the supposition

recent authors have already shown that that statement is erroneous, and that this enormous length was made up only by placing a number of broken strobilae together and assuming that they all belong to one individual tape-worm. It is not infrequent to find worms 4^m or even 5^m long. The breadth of the worm varies from about 1^{mm} to 16^{mm}, according to the portion (the neck or the posterior end) measured, the age, preservation of the specimen, and the extent of contraction. The anterior portion is generally whitish, while the posterior end is frequently of a yellowish or orange color.

Specimens of worms, agreeing in regard to the shape of the head and presence of the blind sacs, vary considerably in form, but it is not thought best to make separate species for these variations, as it is believed that most of them may be accounted for by contraction.

The *scolex* varies from 0.368-0.72^{mm}; the suckers measure about 0.3 broad by 0.256^{mm} long; the opening is slit-form. The neck is extremely variable, in some cases very thin, in others quite thick (contraction). Segmentation begins from 0.5-2^{mm} back of the head.

Segments 10^{cm} from the head measure 1.5^{mm} wide by 0.24^{mm} long; about 25 sacs are present; the genital anlage is circular in shape, although, in some cases, slight traces of the barrel of the pistol can be seen.

Segments 15^{cm} back of the head measure 2^{mm} wide by 0.19^{mm} long; about 35 sacs are visible; the genital pores are not yet present; the genital anlage is pistol-shaped, and at the median extremity is already divided into two lobes, the anterior destined to form the male canal, the posterior to form the female canals and glands; the lateral point of the anlage (muzzle of the pistol) is close to the edge of the segment in its anterior third. No testicles are visible.

Segments 20^{cm} from the head (Plate VI, Fig. 3) measure 3.5^{mm} wide by 0.56^{mm} long; about 40 sacs are visible; genital pores not present; the genital canals become more distinct and the ovary, vitellogene and shell-glands can be distinguished; numerous testicles are present; they occupy the median line as well as the rest of the median field. Zschokke states that the testicles of *T. expansa* are arranged in two triangles, one each side of the segment, as is the case in *M. trigonophora* (see below). By far the greater number of segments of *M. expansa* which have been examined do not present this relation, although in a few segments of this species which were collected at Paris,

that these bottles contained only one specimen each, I was assured in the most positive terms that the worm "210 feet long" was *entire* at the time of measurement. Further conversation, however, elicited the fact that the worm had not been measured in the way zoölogists take measurement, *i. e.*, by placing the parasite upon a table and measuring its length while lying undisturbed, but that the freshly expelled cestode was in a stool of warm water; one end of it was lifted up and the length taken by means of a yard-stick while the parasite was in a *perpendicular position*. In this way its own weight would, of course, cause an *enormous* extension, and the length of "210 feet" could be easily obtained.—C. W. S.

the triangular arrangement of the testicles is very distinct. This character appears in the same strobila with a quadrangular arrangement, but as most of the segments show the quadrangular arrangement, it is believed the triangular arrangement in the older segments of this species forms an exception. In Rudolphi's specimens the testicles are not visible.

Segments 30^{cm} from the head measure 5^{mm} broad by 0.4^{mm} long; the genital pore has pierced the anterior third of the margin of the segment; the canals are perfectly distinct; the female glands are all visible; the entire remaining portion of the median field is crowded with testicles 56 μ in diameter. (As the segments were subjected to pressure in making the microscopic preparations, this 56 μ is probably larger than normal.)

The topography of the female glands, canals, vagina, cirrus, nerves, and the longitudinal canals agrees with *M. trigonophora* (see below, p. 39-41), so it is useless to repeat the description here. The only difference noticed was that the vagina and cirrus are more exactly on the same transverse plane (Plate VI, Fig. 4). Zschokke states that, as a rule, the vagina is ventral while the cirrus is dorsal, but I have found that the vagina is always ventral on the right side and dorsal on the left side.

The uteri (Plate VI, Fig. 6) come more plainly into view in segments 80-90^{cm} from the head, while the genital glands begin to atrophy. As the segments grow wider the interproglottidal sacs increase in number.

In segments 150^{cm} from the head the uteri are fully developed; they extend into the lateral fields dorsally of the longitudinal canals. The testicles are no longer visible; but the receptaculum seminis still persists; this organ is generally somewhat longer than in *M. trigonophora*. In the remaining segments the ova come more plainly into view, and finally the segment represents a bag of ova.

Ova.—The eggs measure 50-60 μ in diameter, the bulb of the pyriform apparatus 20 μ .

SPECIFIC DIAGNOSIS.

The specific diagnosis of this form is as follows:

Moniezia expansa (R., 1810) R. Bl., 1891.—Strobila attains 4-5^m in length; anterior portion usually whitish, posterior portion generally yellowish. Head 0.36-0.7^{mm} in diameter, obtuse, more or less square, slightly lobed; suckers distinctly raised, apertures directed diagonally forward. Segments always much broader than long; end segments attain 16^{mm} in width and are quite thick. Topography of nerves, longitudinal canals, genital canals, and female glands similar to *M. planissima*; testicles usually arranged in a quadrangle, rarely in two triangles except in the younger segments. Interproglottidal glands localized around blind sacs which open between segments. Ova 50-60 μ , bulb of the pyriform apparatus 20 μ .

Type specimen is in the Königl. Museum für Naturkunde, Geheimrath Prof. Dr. Möbius, Direktor, Invalidenstrasse, Berlin, Germany. Several segments of the type are in the Bureau of Animal Industry, and in the private collection of C. W. Stiles. Typical specimens will be sent to museums and specialists exchanging with this Bureau. C. W. S.

(5) *Moniezia oblongiceps* sp. n., 1893.

[Plate VII, Figs. 1-4.]

Host.—*Coassus* sp. (S. & H.)*Geographical distribution*.—Washington, D. C., imported from the Island of Trinidad, South America.

In a post-mortem examination of a *Coassus* sp? recently imported for the National Zoölogical Park at Washington, D. C., from South America, two specimens of an adult cestode were found which bear a great resemblance to *M. expansa*, but which differ from it in the form of the head and segments as well as in general appearance.

While for a long time we were inclined to look upon this as a simple variety of *M. expansa*, we incline at present to the view that the parasite in question represents a distinct species, which, however, is very closely allied to *M. expansa* of cattle and sheep. If only a few segments of the worm were in our possession we should undoubtedly determine them as identical with that form, but with two well preserved specimens before us it has been decided that they represent a true species.

ANATOMY.

General appearance.—Two strobilæ provided with heads measured respectively 97^{cm} and 88^{cm} in length. A third strobila, which evidently belonged to one of those provided with a scolex, measured 31^{cm} long. The head is not distinctly separated from the neck; the segments gradually increase in breadth to 50^{cm} from the head, where they reach the maximum of 9^{mm}; from this point they diminish in breadth and increase in length so that the end segments measure 6.5×1^{mm}. All the segments are quite thin. When fresh the worms have a very light yellowish tinge.

Scolex.—The head measures (preserved) 0.48–0.56^{mm} broad; it is somewhat narrower in its dorso-ventral diameter. The same measurements are preserved for a short distance back of the head, so that the latter is not distinctly separated from the body. While the head of *M. expansa* viewed *en face* is more or less square, this head is distinctly oblong. The suckers (0.19 in diameter) are situated at the four corners. The openings in our specimens are slit-form and directed half forward, half corner-wise. The suckers are not so distinctly raised as in *M. expansa*.

In Fig. 2b, Plate VII, the portion back of the head is broader than the head; in another specimen (Plate VII, Fig. 2), the diameter of the head is preserved for about 2^{mm}, then it decreases somewhat for a very short distance, and finally increases again. This variation is due entirely to contraction.

Segments 10^{cm} from the head measure 5^{mm} wide by 0.16 long; about 30-36 sacs are present; no testicles are visible, but the genital anlage has the characteristic pistol shape; the pore is not present; the median end of the anlage is already differentiated into a male and female lobe. In segments measuring 5^{mm} broad by 0.48 long, the pore is just on the point of piercing the margin in its anterior third, the outer cuticle invaginating to meet the genital canals; the cirrus-pouch is not yet formed; the male and female canals are separated in their entire length; female glands are all formed but are small. The remaining portion of the median field is occupied by testicles which are found in the median line as well as elsewhere; the interproglottidal sacs have increased in number in proportion to the width of the segment.

Segments 21^{cm} from the head measure 6^{mm} broad by 0.48^{mm} long; the genital pore is present; all of the organs have increased in size; the testicles have increased in number but are less numerous and smaller than those of *M. expansa*; the genital organs and the longitudinal canals present the same topographical relations found in the other species of *Moniezia*; copulation has taken place in segments 22^{cm} from the head. The canal inside the cirrus is frequently quite wide. This widening is sometimes seen in other forms also, but it has never been seen so pronounced as in the worm now under consideration. The genital papillæ are much more prominent than in any other species examined except *M. denticulata* and *Th. Giardi*.

Segments 30^{cm} from the head measure 6.75^{mm} broad by 0.48^{mm} long. Segments 40^{cm} from the head measure 8^{mm} broad by 0.56^{mm} long; the uteri become more prominent, while the female glands begin to atrophy. Segments 50^{cm} from the head reach the maximum breadth of 9^{mm}, while in the next 40^{cm} they decrease in breadth to 6.5^{mm} by 1^{mm} long. In the last segments the female glands and testicles have entirely disappeared.

Eggs.—The ova measure 48-60 μ in diameter; the bulb of the pyriform organ 16-20 μ ; the horns are very short, 8-10 μ .

SPECIFIC DIAGNOSIS.

The specific diagnosis of this cestode is as follows:

M. oblongiceps sp. n., 1893.—Strobila attains 97 (probably 120 or more) centimeters in length; yellowish. Head not distinctly separated from neck; oblong when viewed *en face*, the breadth (0.48-0.56^{mm}) being greater than the thickness; suckers 0.19 in diameter, not prominently raised, situated at the four corners; openings slit-form and directed diagonally forwards. Segments always broader than long, rather thin; maximum breadth (about 50^{cm} from head) 9^{mm}; end segments 6.5 wide by 1 long. Topography of organs same as in *M. expansa*; testicles less numerous and smaller. Interproglottidal glands arranged around sacs. Eggs 48-60 μ ; bulb of pyriform organ 16-20 μ ; horns 8-10 μ .

Type in the Bureau of Animal Industry, U. S. Department of Agriculture.
S. & H.

(6) *Moniezia trigonophora* sp. n., 1893.

(Plates VIII, IX.)

Synonymy.—*Tania expansa* Curtice, *ex parte*, specimens in the collection of the Bureau of Animal Industry. *T. expansa* McMurrich, see p. 30. *T. Benedeni* Neumann, *ex parte*.

Host.—Sheep (Neumann, Curtice, McMurrich, Stiles, Hassall).

Geographical distribution.—North America: U. S. A., Washington, D. C. (Curtice, Stiles, Hassall); Blairsville, Pa. (Stiles); Canada (McMurrich). France (Neumann).

LITERATURE.

McMURRICH. See above, *M. expansa*, p. 27.

STILES. Notes sur les Parasites—14: Sur le *Tania expansa* Rud.; Compt. rend. d. l. Soc. d. Biol., Paris, 1892, p. 165. (*T. Benedeni* de Neumann.)

——— Bemerkungen über Parasiten—17: Ueber die topographische Anatomie des Gefäßsystems in der Familie *Taniadae*; Centralblatt f. Bakt. u. Par., 1893, bd. XIII, p. 465.

HISTORICAL REVIEW.

McMurrich (1) mentions a tapeworm epizootic in Canada, and diagnoses the parasite as *Tania expansa*. From his figures and description, however, we suspect that the worms belong to this new species.*

In September, 1891, Stiles received instructions from Hon. Edwin Willits, Acting Secretary of Agriculture, to proceed to Blairsville, Pa., and study an epizootic among sheep, which was reported as existing at that place. He found that the sheep were infested with a large number of worms, which were undoubtedly the cause of the trouble. *Strongylus contortus* was present in the fourth stomach in such numbers that it was almost impossible to see the mucous membrane. Besides this, all of the sheep examined contained large numbers (10–50) of tapeworms belonging to the species here described. Upon comparing these worms with parasites in the Bureau collection it was found that Curtice had collected a number of the same kind from sheep slaughtered at Washington, D. C., and had determined them as *Tania expansa*. As stated above, Neumann's specimen of *M. Benedeni* also agrees with this form.

ANATOMY.

General appearance.—The worms are of a cream color when fresh. The head is quite small; the strobila attains the length of about 1.6 meters. The segments are very sharply defined, in nearly all cases broader than long, although some segments were found which were almost square, or even longer than broad. The largest segments are generally 6–7^{mm} broad by 2^{mm} long.

Scolex.—The head (Plate VIII, Figs. 2–2c) in preserved specimens measures 0.624–0.704^{mm} broad; in a balsam-preparation of the same form

* Through the kindness of Prof. McMurrich I have been able to examine the worm mentioned by him as *T. expansa*, and have verified the interpretation given above. There is no doubt that the worm is identical with *M. trigonophora*.—C. W. S.

it measured 0.768^{mm} broad. The head passes imperceptibly into the neck, which frequently shows a pseudo-segmentation; the true segmentation begins 2^{mm} back of the head, where the worm is 0.48 broad. The suckers (under pressure) measure 0.272 in diameter. In alcohol specimens the opening is slit-form.

Plate VIII, Fig. 2, represents the head of the smallest worm found. The strobila measured 2.7^{mm} long; segmentation is visible, but no genital organs are developed. The head is pear-shaped and measures 0.48 broad; the suckers (0.256 by 0.2) are directed diagonally forwards—dorso- (or ventro-) laterally.

Segments 50^{mm} from the head measure 2^{mm} wide by 0.13 long; 10–14 interproglottidal sacs are present but indistinct; the genital anlagen are indistinct; no testicles can be seen; 75^{mm} from head, about 18 sacs are visible; no testicles are developed. The genital anlage is represented by a round clump of tissue on each side of every segment.

Segments 10^{cm} (Plate VIII, Fig. 3) from the head measure 0.4^{mm} long by 4.5^{mm} broad; the genital pores are not present; the genital canals are but little differentiated; the median end-knob of the pistol-shaped genital anlage is indistinctly divided into two lobes; the testicles and ovaries are not visible. At the border between every two segments a number (20–27) of blind sacs are distinguishable; 150^{mm} from head the segments are 3.5^{mm} wide by 0.4^{mm} long; testicles begin to develop; the genital canals gradually become more distinct.

In segments 190^{mm} from the head the testicles are numerous. In segments 200^{mm} from the head, the female anlage becomes quite distinct from the male ducts. It sends a prolongation toward the center of the segment; a portion branches from this toward the posterior edge of the segment and becomes the anlage of the vitellogene gland; another portion extends toward the anterior edge; its end spreads and forms the anlage of the ovary. Between these two anlagen is seen the anlage of the shell gland. The portion of the male anlage just median of the longitudinal canals begins to form convolutions, and its end, which is rather thin, can be traced past the female glands a short distance toward the median line of the segment. At about this stage the canals, which were at first solid, begin to show a lumen.

Segments 30^{cm} (Plate VIII, Fig. 4) from the head measure (balsam preparation) 6^{mm} broad by 0.88 long. The interproglottidal sacs have increased in number (30–36) and size. The genital pores have pierced the cuticle; they are invariably situated in the anterior half of the margin. The cirrus-pouch is well developed; the lateral portion of the vas deferens (*vesicula seminalis*) is much convoluted and filled with spermatozoa; the median portion of the vas deferens crosses the ovaries; 150–240 testicles are present in each segment and are arranged in two triangles; the long leg (base) of the triangle is nearly parallel to the posterior edge of the segment, the short leg (perpendicular) parallel with the lateral margin; the hypotenuse runs from the antero-lateral

portion to the posterior edge near the median line. While the testicles are generally included within these limits, they are frequently found outside the same, so that the triangles must be considered as a convenient but not rigid diagram.

Occasionally testicles were found in the lateral fields. This shows an initial step in the wandering of the testicles from the median to the lateral fields, a tendency which reaches its highest development in *Th. Giardi*. In the female genital organs, the canals present distinct lumens; the vagina is sharply separated from the receptaculum seminis; the three glands are distinctly differentiated from each other, both anatomically and histologically.

Segments 60^{cm} (Plate IX, Fig. 4) from the head measure (under pressure) 6^{mm} broad by 1^{mm} long. There are 35-37 interproglottidal sacs to each segment. Copulation has already taken place, as is shown by the presence of spermatozoa in the receptaculum seminis. The various genital organs, with the exception of the uteri, can all be distinguished. The female glands form a circular clump plainly visible to the naked eye on stained specimens. For a careful study of the anatomy, segments 60-80^{cm} from the head are well adapted. The segments are nearly the same width (6-6.5^{mm}), but increase gradually in length (1-1.36^{mm}). The posterior flap of every segment overlaps the next segment by 0.24^{mm}. The arrangement of the testicles in two triangles is general, but testicles are frequently seen in the median line. The arrangement of the female genital glands in a rosette is very striking. In the general topographical relations of the organs there are noticed several important characteristics which agree with *M. planissima*, i. e., the genital pores are in the anterior half of the margin; on the right side the vulva is ventral of the cirrus-pouch, and on the left side the cirrus-pouch is ventral of the vulva; the two organs are, however, not exactly on the same transverse plane, but the vulva is regularly found slightly posterior to the cirrus. The genital canals of each side, in passing to the median field, cross the two longitudinal canals and nerve dorsally, and the vas deferens passes the ovary dorsally. The relative position of the genital and longitudinal canals, or of the ovary and vas deferens, gives us two excellent points by which we can immediately distinguish the dorsal from the ventral surface.

Male genitalia.—The description of the cirrus-pouch of *M. planissima* applies almost equally well to this species, except that the layer of ciliary projections is not well developed; in fact, in many cases it was impossible to find it. As a general rule, a genital cloaca is present instead of a genital papilla, even when the penis is extended. That, however, is simply a matter of contraction, for, as seen below (*Th. Giardi*), the development of the papilla in its fullest extent depends upon the absence of the cloaca and vice versa. In the genus *Moniezia*, however, there is a distinct collar around the genital openings even

when the genital cloaca is reduced to a minimum. From the base of the cirrus-pouch to the free end of the extended penis is 0.32^{mm} ; to the base of the cloaca, 0.16 . The median half of the pouch is considerably constricted, owing to the presence and contraction of a thick layer of circular muscles. The vas deferens branches freely, the branches running to the testicles, which are about $48\ \mu$ in diameter.

Female genitalia.—The only practical difference observed between the vulva of this species and that of *M. planissima* is that the former has a position slightly posterior to the center plane of the cirrus-pouch. The vagina is about 0.4^{mm} long; the histology agrees with that of *M. planissima*, except that the muscular layer is slightly more developed. The ciliary layer is somewhat less developed; in fact, in most cases, it has not been possible to recognize it at all.

The receptaculum seminis lies dorsally of the ovary, but generally presents a slightly different aspect from that of *M. planissima* or of *M. expansa*; while in those latter species it was rather long and not very wide, in this species it is much shorter in proportion to its breadth (0.28^{mm} long by 0.144). The wall consists of a simple layer of flat epithelium; in many cases it has been impossible to distinguish any basement membrane, while in several cases it was distinctly visible. As a general rule it may be stated that the receptaculum seminis runs diagonally from before backwards instead of parallel with the anterior edge; this, however, may be subject to variation according to the state of contraction of the segment.

From the ventral side of the receptaculum seminis (Plate VIII, Fig. 5; Plate IX, Fig. 3) near its median extremity a canal takes its origin and makes a bend ventrally. In this canal the ova come in contact with the spermatozoa (fertilization canal or first portion of the oviduct). The canal can be traced to the calyx of the ovary, with which it is connected by a constricted portion, as in the case of *M. planissima*.

A short distance from the receptaculum seminis this oviduct gives off a canal dorsally, which, after one or two convolutions, enters the shell-gland and runs to its center. Here it meets with the vitello-duct, and from their point of juncture (ootyp) the third portion of the oviduct extends towards the uterus after making several convolutions in and outside of the shell-gland. As it passes towards the anterior portion of the segment it runs directly dorsal of the upper end of the first portions of the oviduct and empties quite suddenly into a cavity elongated laterally, which is the uterus. The exact positions of these canals vary slightly in different segments.

Histology.—The histological structure of all these canals agrees very well with that described in *M. planissima*; *i. e.*, there is a lining epithelium with basement membrane; the constriction at the upper extremity of the oviduct is surrounded by circular fibers. The ova follow the same course as those in *M. planissima*; *i. e.*, from the calyx of the ovary they descend through the constriction to the first portion of the

oviduct (fertilization canal), come in contact with the spermatozoa, descend through the second division of the oviduct to the middle (ootyp) of the shell-gland, coming in contact with the vitelline matter and egg-shell secretion; they then pass through the ascending (or third) portion of the oviduct to the uterus.

Excretory canals.—The ventral canals are much larger than the dorsal canals, and are connected at the posterior border of each segment by the transverse canal. As a rule they lie laterally and ventrally of the dorsal canal; rarely a projection of the ventral canal extends somewhat dorsally of the dorsal canal (probably a matter of contraction). The lumen of the ventral canals measures 0.368^{mm} by 0.064^{mm} , being longer laterally than dorso-ventrally. It is lined by an extremely thin cuticle, surrounded by parenchyma. The muscle-fibers of the body cluster around it so that it sometimes appears as if they formed a regular layer around the lumen.

The dorsal canal seldom measures over 24μ by 9μ ; its cuticle is thicker than that of the ventral canal. Sudden swellings are seen, such as are described below in *Th. Giardi*.

Interproglottidal glands.—The cells of the interproglottidal glands are grouped, as stated above. Sections through these (Plate IX, Figs. 1-2) show that numerous large cells are grouped around small blind sacs, which empty between the proglottids. The entire structure is about 0.15^{mm} in diameter. The nuclei of the cells measure 4μ . While the nuclei of these cells in *M. planissima* generally contained only one nucleolus, two nucleoli are observed to be the rule in this species; the cells converge towards the sac. The wall of the sac has the same histological structure as the vagina and cirrus, *i. e.*, the lumen is surrounded by a layer of ciliary projections (5μ), which is followed by a nearly homogenous layer (3μ) containing nuclei. It was seen above that the vagina was not an invagination of the outer cuticular wall, and the similarity of histology between the vagina and these sacs would naturally lead one to assume that these sacs also are not invaginations in the strictest sense of the term.

Segments 100^{cm} from the head measured, under pressure, 6.5^{mm} broad by 1.12^{mm} long (median line), 1.28 (on the side). The blind sacs have increased to about 40 in number. In segments 100^{cm} – 150^{cm} from the head the breadth varies from 5.5 to 6.5^{mm} , the length from 1.25 – 2^{mm} . A decided change is brought about in the anatomy of the segment by the change in the genital organs. The testicles, ovaries, vitellogene, and shell-glands gradually atrophy. The two uteri (Plate IX, Figs. 5, 6) come more plainly into view, one on each side of the segment; they form numerous folds and gradually occupy the lateral and median fields, generally leaving, however, a clear space in the median line. The receptaculum seminis is full of spermatozoa and very prominent.

In connection with the above description it must be mentioned that the point (*i. e.*, the distance from the head) where the various organs

begin to develop varies greatly in different specimens. In some cases the interproglottidal sacs appear before the genital organs, in other cases not until after. In several specimens of this species the sacs were very few or even entirely absent (young specimens), while in one specimen they were fused into a regular line very similar to the interproglottidal line of *M. planissima*. This is undoubtedly to be looked upon as a reversion.

In the end segment of one specimen was found a single median but normally developed set of female genital organs with a single lateral pore. This probably represents a reversion to a former type with single pores.

The mature ova measure $52\ \mu$ — $60\ \mu$ in diameter; the bulb of the pyriform apparatus is $20\ \mu$ — $24\ \mu$; the horns ($12\ \mu$ — $15\ \mu$ long) end in a knob; the hooks of the embryo measure $9\ \mu$ long. In this species it was plainly seen that the pyriform body was surrounded by a membrane, a detail which was not so clear in *M. planissima*.

SPECIFIC DIAGNOSIS.

The specific diagnosis of this form is as follows:

M. trigonophora sp. n., 1893.—Strobila attains 1.6–2^m in length, cream to whitish in color. Head 0.624^{mm} — 0.704^{mm} broad; suckers not distinctly raised, 0.256 by 0.2^{mm} , slit form. Neck filiform, 2^{mm} long. Segments generally broader than long, although end segments are occasionally seen which are square or even slightly longer than broad; rarely over 6^{mm} broad by 2^{mm} long. Topography of longitudinal canals, genital canals, and female organs the same as in *M. planissima* and *M. expansa*; testicles usually arranged in two triangles; generally absent from the median line of segment. Genital pore never behind the middle of the segment. Ova 52 – $60\ \mu$; bulb of pyriform apparatus 20 – $24\ \mu$; horns 12 – $15\ \mu$.

Type in the Bureau of Animal Industry, U. S. Department of Agriculture. Typical specimens will be sent to museums and specialists exchanging with this Bureau.

S. & H.

C. Denticulata Group. (*M. denticulata*, and *M. alba*.)

Interproglottidal glands absent.

(7) *Moniezia denticulata* (R., 1810) R. Bl., 1891.

[Plate V, Figs. 4–7.]

Synonymy.—*Tania denticulata* Rudolphi, 1810; *T. denticolata* (R.) Perr., 1882; *Moniezia denticulata* (R.) R. Bl., 1891; (*Alyscimnthus denticulatus*, Blainville, after Baird, 1853).

Host.—Cattle (Rudolphi).

Geographical distribution.—? (Alfort Museum, Rnd.'s specimens.)

LITERATURE.

(1) RUDOLPHI. Hist. nat. ii, 2, pp. 79–81.

(2) ———. Ent. Syn., p. 145.

(3) GURLT. Lehrbuch der pathologischen Anatomie der Haussäugethiere, 1831, i, p. 381, taf. x, figs. 3–4.

- (4) CREPLIN. Endozoologische Beiträge. 1. Ueber *Tænia denticulata* Rud. und *Tænia expansa* Rud.; Wiegemann's Archiv. f. Naturg., 1842, i, pp. 315-327.
- (5) DUJARDIN. Histoire nat., p. 578.
- (6) DIESING. Syst. Helm., i, p. 498.
- (7) BAILLET. Histoire naturelle des Helminthes des principaux mammifères domestiques, 1866, pp. 162-163.
- (8) DAVAINÉ. Traité, etc., 1877, p. liii.
- (9) ZÜRN. Die tierischen Parasiten, p. 197.
- (10) PERRONCITO. I Parassiti, etc., 1882, p. 240, figs. 101-102.
- (11) LEUCKART, R. Bandwürmer; Koch's Encyclopädie der gesammten Thierheilkunde, 1885, pp. 399-400. *T. denticulata* under *Dipylidium*.
- (12) PERRONCITO. Trattato, etc., 1886, p. 232, fig. 78 (after Gurlt), 80-81 (orig.).
- (13) RAILLIET. Éléments, etc., 1886, p. 260.
- (14) NEUMANN. Traité, etc., 1888, 1 éd., p. 377.
- (15) R. BLANCHARD. Sur les Helm. des Anthr. (foot note); Mém. d. l. Soc. Zool. d. France, 1891, p. 187.
- (16) MONIEZ. Notes sur les Helminthes, VI, 4; Rev. Biol. du Nord de la France, 1891, 3 pages.
- (17) R. BLANCHARD. Notices Helmin. 2. sér., 6; Mém. d. l. Soc. Zool., 1891, p. 444.
- (18) NEUMANN. Traité, etc., 2 éd., 1892, p. 401, Fig. 183. Engl. Transl., pp. 412, 429; Fig., 183 (*M. Benedeni*).
- (19) CURTICE, C. Parasites, etc., 1892.
- (20) Stiles. Bemerkungen über Parasiten—17: Ueber die topographische Anatomie des Gefässsystems in der Familie *Tæniidæ*; C. f. B. u. P., 1893, bd. XIII, p. 465.

HISTORICAL REVIEW (1810-1892).

Rudolphi gives as diagnosis of *Tænia denticulata*:

Tænia: capite tetragono, collo nullo, articulis brevissimis, foraminibus marginalibus oppositis, lemniscis dentiformibus.

Camper. in Beschäf. d. Berlin. naturf. Freunde, IV, p. 39.

Gmelin. Syst. Nat., p. 3074, n. 55. *Tænia ovina*, β *bovis*.

Carlisle. Trans. Soc., Linn. II, tab. 25, Fig. 15-16. *T. ovina*, *bovis*.

Rudolphi. Hodæpor vol. I, p. 81; vol. II, p. 39. *T. denticulata*.

Hab. in Bove. Camperus a bove; Havemannus, Scholæ Vet. Hannov. Director merittissimus, a vitulo (solitariam, capite destitutam); Chabertus a vacca copiose, dejectam observaverunt, hic etiam in vaccæ ventriculo quarto reperit. Specimina mea ex Museo Scholæ Veterinariæ Altorfensis ditissimo.

Descr. Vermes quindecim ad sedecim pollices longi, antice duas ad quinque lineas, postice fere pollicem lati; coloris albidii, vel grisei.

Caput exiguum, tetragonum, latiusculum, *osculis* quatuor, anticis, subcontignis, subglobosis, horum apertura exigua, orbiculari. *Collum* nullum. *Articuli* aliquot capiti proximi angusti, mox vero latiores, tandem latissimi et subæquales fiunt, ita tamen, ut in uno alterove specimine media vermis pars paullo angustiores et simul longiores objiciat; omnes ceteroquin brevissimi, ut longitudo latissimorum vix lineam, plurimorum ne dimidiam quidem excedat. Margines articulorum postiei crenati sive undulati superficiem insequentium qua partem tegunt; laterales (anterioribus nonnullis, rarius mediis quibusdam articulis exceptis) obtusiusculi, foramine utrinque medio, opposito, insignes, e quo denticulus acutus, leviter reflexus et duriusculus (lemniscus) exseritur. Substantia mollis, plus minus crassiuscula, ut crassities interdum lineam adæquet. Ova in substantia media cumolata, ovariis regularibus mihi non vicis.

Of the articles which Rudolphi mentions, Camper has not been consulted. It does not seem that Carlisle's figures could refer to this

species, and it seems doubtful whether Gmelin's reference is to *denticulata*.

Gurlt (3) obtained Rudolphi's specimen and gave two figures, which are copied (Plate v, Figs. 4, 5).

Creplin (4) does not believe that Carlisle's drawings refer to *T. denticulata*. Mayer's drawings (Analecten f. verg. Anat., 2. Samml., Figs. 4, 5) he thinks are *T. expansa*, and he is skeptical whether Camper's and Havemann's specimens were *T. denticulata*. Creplin himself obtained Rudolphi's original specimens, and says in regard to them that there was only one specimen provided with a head; this specimen measured 1-2'' long. The head was rather four-cornered, and sat like a knob on the end of the anterior cone-shaped portion; the suckers formed the blunt corners of the head and opened directly in front (Plate v, Fig. 5). The portion immediately following the head was wrinkled, but it was not clear whether these wrinkles represented true segments, hence it was doubtful whether a neck was present or not; this portion widened very rapidly. All the segments were very short; the lateral edges were convex; the posterior edge covered the following segment for some distance. The broadest segments he had were about $\frac{1}{4}$ '' wide by 1''' long, thick and bloated. Double pores were present. *These were situated immediately behind the posterior edge of the next anterior segment, with the exception of a few cases where they were nearer the middle;** from the pores the lemniscus (cirrus) protruded; the latter was short, thick, and rather conical, on the end truncate.

Creplin then describes the ova with the pyriform apparatus. As diagnosis of *T. denticulata* he gives the following:

T. capitis tetragoni, parvi osculis angulos ipsius efficientibus, magnis, antrosum apertis, collo subnullo, articulis omnibus crassis, celeriter insigniterque latitudine, paulum longitudine crescentibus, anterioribus ideo brevissimis, reliquis omnibus perbrevis atque admodum latis, marginibus horum lateralibus convexis, postico protracto et ita sequentis articuli partem anteriorem circumcirca late tegente, foraminibus articulorum latiore (et lemniscis) marginalibus oppositis secundis. (Articuli postiei incogniti. Ova globiformia.)

Dujardin (5), Diesing (6), Davaine (8), and Zürn (9) do not add any original observations on *T. denticulata*, but give very short diagnoses.

Baillet (7) states that *T. denticulata* measures 35 to 40 or even 78^{em} in length. He gives the measurement of the eggs as 0.09-0.095^{mm}, which, as Moniez has already pointed out, is an error. In his description there is little which aids us in determining this species.

Perroncito (10) considers *denticulata* rather as a variety of *expansa* than as a separate species, but it is evident from his figures and description that he did not have a true *denticulata* before him. His figures seem to me to resemble *expansa*, while a part of his description applies equally well to *expansa* and *planissima*.

*The italics are mine. From my drawing of Rudolphi's type (Fig. 6) it is evident that Creplin made his statement on loose segments, and mistook the anterior for the posterior edge.—C. W. S.

Leuckart (11) has published by far the best description of this species that has yet appeared (Creplin excepted). It is based upon a specimen in the Leipsic museum. Leuckart states:

Eine zweite, dem letztern eigenthümliche Art ist die gleichfalls den Dipylidien zugehörige *Tania denticulata* Rud. In ihrer Statur der *Tania expansa* ähnlich, unterscheidet sie sich aber nicht bloss durch eine ungleich geringere Grösse, sondern schon auf den ersten Blick, gewisser weiterer Eigenthümlichkeiten einstweilen nicht zu gedenken, durch ein gedrungeneres, derberes und feisteres Aussehen. Ein Exemplar von 320^{mm} Länge hat schon 25^{mm} hinter dem Kopfe eine Breite von 4^{mm} und in dem 100^{mm} langen hinteren Körper eine solche von 13^{mm}. Die Länge der letzten Glieder beträgt 1.5^{mm}. Bei grösseren Würmern soll die Breite sogar auf 26^{mm} heranwachsen. Der Kopf ist etwas grösser als bei *Tania expansa* (0.7^{mm}) und mit grösseren Saugnäpfen versehen, die ihm eine mehr viereckige Form geben. Auf ihn folgt auch hier zunächst ein dünnerer Abschnitt, der aber sehr bald schon sich verbreitert und gliedert, und weit rascher als bei *Tania expansa* zu den späteren Dimensionen heranwächst. Dabei sind die Glieder aber durchschnittlich kürzer als bei der letztern. Die auch hier mit zunehmender Grösse allmählig immer stärker hervortretenden manschettentförmigen Gliedränder sind gewöhnlich deutlich gewellt und auch über die Seitenkanten hinans fortgesetzt, so dass die hinteren Ecken stärker prominiren und an den letzten und grössten Gliedern zahnartig nach aussen vorspringen. Die reifen Eier gleichen denen von *Tania expansa*, bleiben aber mitsamt dem Embryonalkörper in ihren Dimensionen um Einiges hinter denselben zurück.

Leuckart seems to think that this species is not an uncommon parasite, although, as he has recently written (personal correspondence), this opinion is based upon report more than upon his own observation.

Railliet (13) states that the eggs are cuboid and twice as large as those of *T. expansa*.

Neumann adds nothing new to our knowledge of this parasite in the first edition of his *Traité* (14).

R. Blanchard (15, 17) places *denticulata* in his new genus *Moniezia*.

Moniez (16) states that *denticulata* is frequent in sheep killed at Lille. He gives as characteristic of this parasite that the segments are opaque and thick, and the square head is different in shape from that of *expansa*. Moniez also cites Baillet's paper, and discusses Creplin's article.

I am at a loss to know how to judge this article by my distinguished colleague, for, although his statements are concise, it was found upon comparing specimens of the parasite he determined as *T. denticulata* that they did not agree with Rudolphi's specimens. Hence I am compelled to assume, for the present at least, that Moniez has not examined the true *M. denticulata*.

Neumann (18) lengthens his diagnosis in the second edition of his excellent work, and gives a figure of the scolex of *T. denticulata*. This figure, however, does not agree with Gurlt's figure of Rudolphi's type, but agrees exceedingly well with my drawing of Moniez's original specimen of *T. Benedeni*. Hence it must be assumed that Neumann also did not find the true *M. denticulata*.

Neumann quotes Humboldt (Berliner thierärztlich. Wochenschrift,

1892) as stating that he found a specimen 45 meters long in a five-year-old cow. Humboldt's statement must, of course, be taken *cum grano salis*. Curtice (19) is the only author who claims to have found this species in America. His specimens, however, which are now in our Bureau collection, are certainly not *M. denticulata*, although they are too macerated to be definitely determined.

From the above review it must be concluded that scarcely anything is known about *M. denticulata*; that the only authentic specimens of this species which have found their way into print are Rudolphi's specimens which he received from Alfort, and the specimen Leuckart described. We know practically nothing of the microscopic anatomy of *M. denticulata*.

Through the kindness of Geheimrath Karl Möbius, the writer has in his possession a few segments of Rudolphi's original *Tenia denticulata*. These segments are filled with ova; they measure 8^{mm} broad by 1.14^{mm} long. The specimens are so old that it would be unsafe to state much in regard to them, but several points are distinctly visible. In the first place, one is immediately struck with the position of the cirrus, which pierces the side of the segment (Plate v, Fig. 6) at or very near its posterior border. The cirrus is stout and blunt; the cirrus-pouch is 80 μ long, the proximal portion (24 μ) being constricted by circular muscles, as observed in other species. The vas deferens could be traced but a short distance; it could, however, be plainly seen that the genital canals cross over into the median field dorsally of the longitudinal canals. It will be noticed also that the lateral field is very narrow, the ventral canal coming very close to, or even crossing, the proximal portion of the cirrus-pouch. The outer canal can be distinctly seen to occupy a position slightly ventrad of the other canal, and to have a thinner cuticle. Hence the former, by analogy, is the ventral, the latter the dorsal canal. The transverse canals were not visible. The genital glands have all been suppressed by the uteri. The uteri were confined to the median field. The ova are round (48 μ in diameter), the embryo measures 12 μ in diameter and is surrounded by a pyriform apparatus. No interproglottidal glands could be discovered.

With the aid of the three figures of this species given in the present paper, it is hoped that some one will be able to determine *Moniezia denticulata* and give an account of its microscopic anatomy.

SPECIFIC DIAGNOSIS.

The following may be accepted as a provisional diagnosis of this species:

Moniezia denticulata (R., 1810) R. Bl., 1891.—Strobila 32–40^{cm} (to 78^{cm}) long; head 0.7^{mm} broad, with proportionately large suckers directed anteriorly; neck absent or very short, anterior segments very short, increasing rapidly in breadth, but gradually in length as they grow older (Gurlt's figure); 25^{mm} from head they measure 4^{mm} wide;

segments may attain 13^{mm} to nearly 25^{mm} (R.) in breadth; mature segments quite thick; segments 8^{mm} broad by 1.14 long are filled with ova. Genital pores are in the posterior half of the margin; in segments of Rudolphi's type they are close to the posterior corner of the segment (cf. also Gurlt's figure); penis prominent and blunt; relation of vas deferens (and probably of the vagina) to the longitudinal canals the same as in *M. planissima*; uteri (always?) confined to the median field; eggs 48 μ , bulb of pyriform body 12-16 μ , horns 8-16 μ .

Type in the *Konigl. Museum für Naturkunde*, Berlin. A few segments of the type are in the private collection of C. W. Stiles.

C. W. S.

(8) *Moniezia alba* (Perroncito, 1879) R. Bl., 1891.

[Plate X.]

Synonymy.—*Tænia alba* Perroncito, 1879; *Moniezia alba* (Perr.) R. Blanchard, 1891; *M. alba* var. *dubia* Moniez, 1891.

Hosts.—Sheep (Perr., Mattozzi, Neumann, Blaise); cattle (Perr., Moniez, Railliet).

Geographical distribution.—Italy (Turin, by Perroncito; Macerata, prov. Marches, by Mattozzi). France (Lille, by Moniez; Alfort, by Railliet). Algeria (by Blaise, after Neumann).

LITERATURE.

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- (2) ——. Ueber eine neue Bandwurmart (*Tænia alba*); Arch. f. Naturgeschichte, 1879, 45. Jahrg., I, pp. 235-237; taf. xvi, figs. 1-10.
- (3) MONIEZ. Note sur deux espèces nouvelles de ténias inermes, *T. Vogti* et *T. Benedeni*; Bull. scient. d. Dept. d. Nord (1879) 1830, p. 163.
- (4) PERRONCITO. I parassiti, etc. 1882, pp. 243, 244, figs. 103-105.
- (5) ZÜRN. Die tierischen Parasiten. 1882, p. 197.
- (6) LEUCKART. Bandwürmer; Koch's Encyclopädie der gesammten Thierheilkunde, 1885; *T. alba*, p. 400.
- (7) RAILLIET. Éléments, etc. 1886, p. 260.
- (8) PERRONCITO. Trattato, etc. 1886, pp. 233-234, figs. 79, 82.
- (9) NEUMANN. Traité, etc. 1. éd., 1886, pp. 378, 382.
- (10) ——. Observations sur les ténias de moutons; Compt. rend. d. l. Soc. d' Hist. Nat. d. Toulouse, 1891, 18 mars.
- (11) BLANCHARD, R. Sur les Helminthes des primates anthropoides; Mém. d. l. Soc. Zool. d. France, 1891, p. 187 (foot note).
- (12) MONIEZ. Notes sur les Helminthes, vi, 5; Rev. Biol. d. Nord d. l. France, 1891, iv.
- (13) BLANCHARD, R. Notices Helminthologiques. 2 sér., 7; Mém. d. l. Soc. Zool. d. France, 1891, p. 444.
- (14) NEUMANN. Traité, etc. 2. éd., 1892, pp. 403-408, Fig. 187; Engl. Transl., pp. 412, 418.
- (15) STILES. Notes sur les parasites—14: Sur le *Tænia expansa* Rud; Compt. rend. d. l. Soc. d. Biol., Paris, 1892, p. 665.

HISTORICAL REVIEW.

Perroncito's Italian article (1) is not at my disposal, but he printed an article (2) in Germany about the same time, and that probably contains substantially the same data. The description reads:

T. candida, multo rarius hinc inde tractu quodam diluto-flavescente vel flavido-terreo (ochreo) intertincta, sat procera, eximie elastica, metr. 0.60-2.50 longa. Statu

recente (mox ex intestino sublata) pallida apparet articulisque s. proglottidibus elongatis, saepe longioribus quam latis, efformata videtur—qui articuli deinde contrahuntur magisque lati quam longi fiunt.

Caput subgloboso-quadrangulare, sat distinctum, mm. 1.40–1.15 latum, vix ultra mm. 1 longum, acetabulis (s. oculis suctoriis) praeditum orbicularibus vel subovalibus, extrorsum ac sursum spectantibus, diametro mm. 0.356–0.456.

Collum breve, saepe depressione circulari constrictum, mm. 1.5–5.320 longum, mm. 0.6–0.912 crassum.

Proglottides, quarum summae mm. 0.020–0.038 longae atque valde angustae sunt, sensim longiores et latiores fiunt, formamque assequuntur rhomboideam, subcampanulaceam, angulis posticis obtusis, ita prominentibus, ut partim proglottidem subsequentem obtegant corpusque taeniae sat acute serratum appareat.—Quae c. decem 1 a capite distant, jam ultra mm. 3 longae et c. tertiam mm. partem latae sunt.—Quae medium taeniae tractum efficient, longitudinem mm. 3–3.5, latitudinem 4–5 mm. praebent atque poris genitalibus manifestis, in quavis proglottide binis, oppositis, inter tertiam proglottidis partem anteriorem et mediam sitis, instructae sunt. Cirrus plerumque prominens ac tenuis, conicus vel cylindraceus, rectus aut varie incurvus (saepius retrorsum deflexus).—Pars taeniae postica crassior, articulis brevioribus ac latioribus, circa 1.5 mm. crassis, mm. 2–3.5 usque ad 4–5, raro 5–6–6.5 longis, mm. 8.5–9.5, raro ultra 10, rarissime 12–14 longis efformata. Proglottides maturae plerumque contractae cernuntur ac valde breves (2–3 mm. longae), uteris binis (utrinque singulo) instructae, qui oculis creberrimis, invicem coniunctis, constant, unde, proglottide puncta, ingens ovulorum copia prorumpit.

Ovula candida, cubica (quavis facie quadrata vel rectangulari, angulis rotundatis, lateribus convexis, mm. 0.048–0.052, subinde etiam 0.058 longis), testam praebent dorso-insculam, chitino efformatam atque guttulis adiposis variae magnitudinis obtectam. Matura embryonem fovit, qui corpore sphaerico at duobus processibus aucto constat ac plerumque situm diametralem in ovulo tenet (corpus enim embryonis plerumque angulo huic aut illi adiacet, dum processus oppositum ovuli angulum petunt). Corpus, scilicet pars embryonis princeps maiuscula, sphaerica et homogena, utriculo constituit, cuius media *protoscolex* inclusus est globosus, protoplasmate homoganeo (dense at pallide granuloso) nucleisque 2–4–5 efformatus atque unculis longiusculis 6 praeditus, quorum ope se in utriculo movet rotatque. Processus supra dicti ab illo corporis latere, quod centrum oculi spectat (exiguo inter ipsorum exortum spatio interjecto) prodeunt, inter se convergentes ac denique aut decussati aut valde appropinquati: alter glochidiatus, scilicet pedicello constat gracili sub-conico, sensim attenuato, apice in cucullum sive appendiculam semilunarem (antrorsum convexam, retrorsum concavam, ad latera utrinque acuminatam ac recurvam) expanso; alter praecedentis pedicello consimilis et aequilongus, exappendiculatus, illius appendiculum denique attingit (cum ipsa tamen non confluent).

The author also adds a short differential diagnosis between *alba*, *expansa*, and *denticulata*. The ten figures are good so far as outline goes, but details are lacking. The parasites were found both in cattle and sheep. By comparing this with Perroncito's next article it is noticed that in giving the measurements above "12–14 longis efformata," *longis* is a misprint. The breadth is here referred to.

Moniez (3) states that he has found this species quite common at Lille, France.

Perroncito (4, 8) gives substantially the same diagnosis in his work on parasites which he gave before (2). Ziirn (5) copies his diagnosis from Perroncito's Italian article. Railliet (7) states that he finds very little difference between this species and *T. expansa*. Neumann (10) states in his analytical table that the segments become longer than broad,

and do not exceed 10^{mm} in width. Blanchard (11, 13) places *T. alba* in his new genus *Moniezia*. Moniez (12) describes a *M. alba* var. *dubia* which, he states, is intermediate between *T. alba* and *T. expansa*.

Prof. Perroncito has kindly sent to me three specimens of his original type material from which he described this species, and Prof. Neumann has sent a specimen of a worm which he diagnosed as *T. alba*. Unfortunately it has been almost impossible to stain Perroncito's specimens satisfactorily, hence it is hazardous to make many definite statements in regard to them.

ANATOMY.

General appearance.—In regard to the anatomy of the segments, there is no doubt that the topographical relations of the vulva, cirrus, vagina, vas deferens, ovary, shell-gland, vitellogene gland, uterus, longitudinal nerves, dorsal, ventral, and transverse canals are the same as found in the other species of *Moniezia*. The testicles are arranged in a quadrangle. No interproglottidal glands of any description could be distinguished. Had sacs been present they would undoubtedly have been discovered, notwithstanding the poor staining, for the heavy cuticular lining of the sacs always stands out prominently, no matter how macerated the specimens are. As the head and segments are totally different from *M. expansa*, and as no sacs are present, it can therefore be stated with certainty that *M. alba* is not identical with *M. expansa*. In some segments of other species, which were even more macerated than Perroncito's three specimens, it has been possible to distinguish linear interproglottidal glands. As they were not seen in Perroncito's specimens, it is assumed that no interproglottidal glands are present in the species *M. alba*.

Ova.—The eggs measure 64–68 μ ; the bulb of the pyriform body 20–24 μ ; the horns 12–20 μ .

Prof. Neumann's specimen is in somewhat better condition than the type specimens, and is evidently identical with Perroncito's *Tania alba*. The total length is 105^{cm}. The head is too distorted to warrant description; it does not, however, bear any very great resemblance to the head figured by Neumann as *T. alba*.

Segments 100^{mm} from the head measure 2^{mm} wide by 0.4 long. The median field is filled with testicles, which are as numerous in the median line as elsewhere. The genital canals and female glands have the characteristic pistol-shape, the muzzle of the pistol being situated near the lateral edge of the anterior third of the segment. The anlagen of male and female canals are distinct; the female glands represent a more or less circular clump, which begins to show a slight differentiation into the component parts. There is no sign of interproglottidal glands. The posterior flap, of course, forms a dark line across the segment, but this is not homologous with the line of glands seen in *M. planissima*.

Segments 320^{mm} from the head show a very noticeable advance in the development of the sexual organs. The proglottids measure 3^{mm} wide by 0.8 long. No interproglottidal glands are visible. The posterior flap of each segment extends but slightly over the next following segment.

The genital pore has pierced the segment in the anterior third of the lateral edge. Cirrus-pouch and vagina are well developed; copulation has already taken place, as is shown by the fact that the receptaculum seminis is full of spermatozoa; the female glands form a large rosette (diameter 0.56) just median of the lateral canals, the vitellogene and shell-glands being almost completely surrounded by the ovarium. The numerous testicles occupy the entire remaining part of the median field.

Segments 55^{cm} from the head measure 4^{mm} wide by 1.44^{mm} long. The uterus now fills the entire median field and a portion of the lateral fields, suppressing the other genital organs, with the exception of the receptaculum seminis and sexual canals. On these segments it could be proved that on one side the cirrus was ventral and the vagina was dorsal, while on the other side the cirrus was dorsal and vagina ventral. As the longitudinal canals could not be plainly seen, it is impossible to state which side is right and which left, but from analogy with the other forms it may be assumed that the side on which the vagina is ventral is right, the opposite side is left. The vagina is slightly posterior to the cirrus-pouch.

Segments 80^{cm} from the head measure 4^{mm} wide by 1.76^{mm} long. The uterus occupies almost the entire segment, and is filled with eggs. It could be proven that the uteri cross into the lateral fields only on one side (from analogy, dorsal side) of the large canal, and that the vagina passes on the same side, so that our analogy of ventral and dorsal, right and left sides, made above, is further supported. The dorsal longitudinal canals could not be distinguished. A transverse canal could be distinguished connecting the two ventral canals, thus making our analogy complete, and establishing the fact that we find the same topographical relations in this species which we find in *M. planissima*. The only point now left undetermined is whether the dorsal canal lies dorsal or ventral of the vagina and vas deferens.

Segments 1 meter from the head measure 5.5^{mm} wide by 3^{mm} long. The proglottids represent sacs filled with the uteri containing eggs; the pores are still plainly visible and a very slight trace of the receptaculum seminis can still be seen.

Eggs.—The ova measure 60–68 μ in diameter, the bulb of the pyriform body 16 μ , the horns 8–10 μ . Perroncito states that the eggs are cuboid, but that character is of course dependent upon reciprocal pressure, and hence of no diagnostic value. The measurements of the ova given by Perroncito and Neumann (in his *Traité*) are 48 μ –52 μ , by Moniez about 70 μ .

SPECIFIC DIAGNOSIS.

The following may be given as a specific diagnosis of this parasite:

M. alba (Per., 1879) R. Bl., '91.—Whitish, 0.60^m–2.50^m long. Head, sub-quadrangular, 1.40–1.15^{mm} broad; suckers slightly lobed, opening small and pointing anteriorly. Neck 1.5–5.3^{mm} long by 0.6–0.9^{mm} broad. Mature segments attain 8–14^{mm} broad by 2–6.5 long by 1.5 thick. Topography of organs same as in *M. planissima*; testicles arranged in a quadrangle; genital pores in anterior half of the segment. Interproglottidal glands absent. Ova 60–88 μ ; bulb of pyriform body 16–24 μ ; horns 8–20 μ .

Type specimens with Prof. Perroncito, Turin, Italy; Bureau of Animal Industry, and private collection of C. W. Stiles, Washington, D. C.

C. W. S.

D. Moniezia. (Undetermined specimens.)

In the Bureau collection there are several very peculiar specimens of the genus *Moniezia*, which at present we are not able to determine specifically. They are all totally different from the forms described above, and it is believed they will be found to represent new species, at least new varieties, as soon as sufficient material can be obtained upon which to base an opinion.

No. 612, Bureau collection, contains a tapeworm from sheep. The interproglottidal glands are linear, but are very short. The head is enormous (Plate XVI, Figs. 5–5a), and totally unlike any head we have ever seen before. It is evidently closely related to *M. Benedeni* and *M. Neumanni*.

Nos. 725 and 732, Bureau collection, contain two heads and numerous loose segments of a worm of the *Expansa* group. The segments, in their microscopic anatomy, agree perfectly with *M. expansa*, but the general appearance of the head (Plate XVI, Figs. 4–4b) and segments is totally different from that species. The segments are very distinct, and appear almost like a string of large broad beads. However, a specimen of *T. saginata* has been found in the Army Medical Museum, the segments of which represent a perfect string of beads, so that we are inclined to doubt the specific value of the peculiar appearance of the segments of these specimens. The parasites came from Virginia sheep.

No. 607, Bureau collection (borrowed from Hassall's private collection), contains a strobila 54.5^{cm} long by 2–2.75^{mm} broad (Plate XVI, Figs. 1–2b). Interproglottidal glands could not be distinguished; specimen is poorly preserved. Genital pores are double; segments become longer than broad. This is the strobila referred to in the discussion of *T. Vogti*. (Cf. 84). Segments measure 2.5^{mm} long by 2 broad, to 1.5 long by 2.75 broad.

C. W. S.

GENERAL SUMMARY OF THE GENUS MONIEZIA.

From the above discussion it will be seen that the species *M. planissima*, *M. Benedeni*, *M. Neumanni*, *M. expansa*, *M. oblongiceps*, *M. trigonophora*, *M. alba*, and *M. denticulata* possess certain characters in com-

mon which compel us to follow Blanchard in uniting them in one genus. Some of these characters could not be traced in all the species owing to a paucity of material; nevertheless, the following will serve as a general summary of the anatomy of these forms.

The scolex is never provided with hooks. The segments are generally broader than long and longer than thick, although the end segments show a tendency to become longer and narrower, in some cases the length becoming equal to or (rarely) even greater than the breadth.

Genital organs.—The first appearance of the genital organs is in segments near the head, in the form of a round clump of tissue on each side of the segment, situated at the edge of the median field just inside the longitudinal canals. Gradually this genital anlage extends across into the lateral fields on the dorsal side of the lateral canals and nerves, assuming a characteristic pistol shape. It then becomes divided into an anterior (male) portion and a posterior (female) portion, which are at first solid, but in which canals gradually develop. The cuticle on the edge of the segment then invaginates at a certain point to meet the canals. At this point is situated the genital pore.

Male genitalia.—The anterior canal mentioned above differentiates, at its lateral end, into the cirrus-pouch; the remaining portion (vas deferens) becomes convoluted and runs towards the median line of the segment, passing on the dorsal side of the ovary. The testicles in many (all?) cases are at first arranged in two triangles, one on each side of the segment. This arrangement remains more or less constant throughout life in one species (*M. trigonophora*), while in (all?) the other species testicles appear in the remaining portion of the median field, thus forming a quadrangle. It is very rare that testicles are found in the lateral fields.

Female genitalia.—The lateral end of the posterior portion of the above-mentioned pistol-shaped genital anlage forms the vagina, the vulva being situated ventrally of the cirrus on the right side of the segment and dorsally of it on the left side. A receptaculum seminis is formed by the portion of the canal inside (median) of the longitudinal canals, while the extreme median lobe-like end differentiates into ovary, vitellogene gland, and shell-gland, together with the canals connecting the same as described on pages 20, 40. The female glands do not develop quite so early as the male glands, but they persist longer.

A uterus is present on each side of the segment. The two uteri form numerous folds, extending into the lateral fields (in all cases?, cf. *M. denticulata*), across the dorsal side of the longitudinal canals and nerves, and also toward the median line of the segment. Generally it is impossible to distinguish the uteri from each other in the median line of the older segments, but in *M. trigonophora* they more frequently remain distinct. As the eggs are developed and the uteri increase in size, the genital glands atrophy, the male organs disappearing before the female organs. Receptaculum seminis, vagina, cirrus-pouch, and the lateral

portion of the vas deferens persist the longest. One segment has been found with a single median set of female organs and a single lateral pore.

The ova are spherical, but by reciprocal pressure they become cuboid. A pyriform apparatus surrounds the oncosphere.

Excretory organs of the segments.—On each side of the segments are found two longitudinal canals running from the head to the posterior extremity, crossing the genital canals on their ventral side. The large lateral canal represents the ventral canal; its cuticular lining is extremely thin; near the posterior border of each segment the ventral canals of the two sides are connected by a transverse canal possessing a thin cuticular lining. The other longitudinal canals lie medio-dorsal of the ventral canals, have a thick cuticular lining, and are not connected in the segments by any transverse canals.

Nerves in the segments.—On each side of the strobila there extends a longitudinal nerve from the scolex to the posterior extremity, running lateral of and parallel with the lateral longitudinal canals. It crosses the genital canals ventrally.

Interproglottidal glands.—A number of the species mentioned above possess glandular structures at the border between every two succeeding segments. The most simple and, as the writer considers, the primitive form of these structures, appears in species of the *Planissima* group, where the glandular cells are arranged in a line parallel to the posterior border of the segment. The longitudinal muscles cause a slight grouping of these gland-cells. In members of the *Expansa* group the gland-cells are concentrated around blind sacs, which open under the flap of the posterior edge. These glands generally appear in segments showing a genital anlage, although the exact distance from the scolex is subject to variation.

R. Blanchard included in this genus the following forms:

Tania expansa R.; *Tania alba* Per.; *T. Benedeni* M.; *T. denticulata* R.; *M. nullicolus* M.; *M. Neumanni* M.; all of which I also admit to the genus.

Blanchard further classes as *Moniezia*:

Tania festiva R., 1819 (*M. festiva* R. Bl., 1891), from *Macropus giganteus*.

Dipylidium latissimum Riehm, 1881 (*M. Goezei* (Baird, 1853) R. Bl., 1891), from rabbits.

Dipylidium Leuckarti Riehm, 1881 (*M. Leuckarti* (Riehm, 1881) R. Bl., 1891), from rabbits.

Tania marmota Frölich, 1802 (*M. marmota* (F.) R. Bl., 1891), from *Arctomys marmota*.

Tania pectinata Goeze, 1782 (*Dipylidium pectinatum* Riehm, 1881; *M. pectinata* (G. 1782) R. Bl., 1891), from rabbits.

Moniez includes in the genus *Moniezia* the species:

Tania ovilla Riv., 1878 (*T. Giardi* M., 1879; *M. ovilla* M. 1891), from sheep.

Thysanosoma actinioides Dies., 1834 (*Tania fimbriata*, Dies.; *M. fimbriata*, Moniez, 1891) from sheep.

Blanchard gives as generic diagnosis the following: "Corps lancéolé en avant. Anneaux serrés, beaucoup plus larges que longs, avec deux pores sexuels opposés."

As the species *Tania marmota*, *Dipylidium latissimum*, *D. Leuckarti*,

D. pectinatum, *T. Giardi*, and *Thysanosoma actinioides* have little in common with the species of *Moniezia* of cattle and sheep, it is proposed to exclude them from this genus.

Anticipating the results obtained below, it will simply be stated here that *Thysanosoma actinioides* and *Th. Giardi*, should be excluded from *Moniezia*, because in these two species we find in each segment a single uterus with ascon-spore like egg-sacs, instead of two uteri. Further, the genital canals pass between the longitudinal canals. For other particulars see the anatomy of these two forms.

Tania marmotæ differs from *Moniezia* s. st., (1) in having a single uterus; (2) the dorsal canal lies lateral instead of median of the ventral canal; (3) the cirrus and vagina do not have the same topographical relations that are found in the genus *Moniezia*.

Diptydium Leuckarti, according to Riehm,* has but one uterus in each segment, while (Riehm, Plate VI, Fig. 5) what is evidently the dorsal canal agrees with *T. marmotæ* in lying lateral of the ventral canal.

The uterus of *D. pectinatum*, according to Riehm, agrees with that of *D. Leuckarti*.

In *D. latissimum*, according to the same author, the uterus is not "ein einfacher, stellenweise erweiterter Schlauch, der in querer Richtung die Proglottis durchzieht, er erweist sich vielmehr in zwei oder drei solcher Schläuche zerspalten, welche sich vielfach mit einander vereinigen und so Inseln von Parenchym einschliessen." Riehm's figure of the uterus is very unsatisfactory, and resembles the vas deferens more than it does a uterus. Whether he has in this case drawn the uterus or not, the anatomy (to judge from his figure) does not agree with that of *Moniezia* s. st.

Hence it is proposed to restrict the genus *Moniezia*, and the following is suggested as a—

GENERIC DIAGNOSIS.

Moniezia R. Bl., 1891. Char. emend.—Head without hooks; segments generally broader than long and longer than thick, end segments showing a tendency to become longer and narrower. Two full sets of genital organs, with two uteri and two lateral pores in each segment. On the right side the vagina is ventral, cirrus dorsal; on the left side vagina dorsal, cirrus ventral. Dorsal canal lies dorso-median of ventral canal. Genital canals cross the longitudinal canals and nerves dorsally. Interproglottidal glands generally present. Calcareous bodies absent from parenchyma. Eggs with well developed pyriform body.

Besides the species mentioned above as belonging to this genus, there are several other forms which may or may not represent new species. This Bureau is not willing to commit itself in regard to the specific determination of specimens Nos. 607, 612, 725, and 732 of its collection, until further material is obtained. We incline, however, to the belief that at least two of these forms will eventually be proven to represent new species of the genus *Moniezia*.

For *M. nullicollis*, see p. 83.

C. W. S.

*Gottfried Riehm, Studien an Cestoden. Inaug.-Diss. Halle, 1881.

PART II.

THYSANOSOMA Dies., 1834.

(9) *Thysanosoma actinioides* Dies., 1834.

[Plate XI, Figs. 1-8.]

Synonymy.—*Thysanosoma actinioides* Diesing, 1834; *Tænia fimbriata* Diesing, 1850; *Moniezia fimbriata* (D.) Moniez, 1891; *Th. actinioides* Dies. (Reestablished, Stiles, 1892.)

Hosts.—Sheep, (Curtice, Hassall, Stiles, *et al.*); *Cariacus rufus*, (Natterer); *C. simplicicornis*, (N.); *C. Nambi*, (N.); *C. paludosus* (*C. dichotomus*), (N.).

Geographical distribution.—South America: Brazil, "Registo do Rio Araguay, Cuyaba, Nas Frechas, und Villa Maria" (Natterer). North America: Colorado, Utah, Nebraska (Curtice); New Mexico (Codweiss, Curtice); California, Oregon, Utah (Collins, Curtice); Missouri (Stewart, Curtice); Washington, D. C. (sheep came from Colorado—Hassall and Stiles.)

LITERATURE.

- (1) DIESING. *Tropisurus* und *Thysanosoma*, zwey neue Gattungen von Binenwürmern aus Brazil; Med. Jahrbuch d. oesterr. Staat. Neue Folge. vii, vide pp. 105-111, taf. III, 1834, *Thysanosoma actinioides*.
- (2) NORDMANN. In Lamarck, *Anim. s. vert.*, 2 éd., III, 591.
- (3) DIESING. *Syst. Helm.*, I, p. 501, 1850, *Tænia fimbriata*.
- (4) ———. Zwauzig Arten von Cephalocotyleen. pp. 32-33; Denkschr. d. M.-N. Classe der K. Akad. d. Wiss. Wien, 1856, *T. fimbriata*.
- (5) KÜCHENMEISTER. On Tape and Cystic worms, with an introduction on the origin of the intestinal worms, by C. T. v. Siebold. Trans. by T. H. Huxley, 1857, p. 42.
- (6) FAVILLE. Report Veterinary Dept. of the Colorado State Agricultural College, January, 1885, *T. expansa*, p. p.
- (7) CURTICE, C. Tapeworm disease of sheep of the Western Plains; Annual Report of the Bureau of Animal Industry, U. S. Dept. Agric., 1887-1888 (appeared 1889); pp. 165-184, 2 plates, *T. fimbriata*.
- (8) ———. Animal Parasites of Sheep, 1890; pp. 89-109, pl. XII (orig.), Pl. XIII (Diesing's figures), *T. fimbriata*.
- (9) NEUMANN. *Traité*, 2 éd., 1892, p. 408, figs. 193-194 (after Railliet, unpublished), *T. fimbriata*.—Engl. Transl., p. 419.
- (10) STILES. Bemerkungen über Parasiten—17: Ueber die topographische Anatomie des Gefäßsystems in der Familie *Tæniadae*; Centralblatt f. Bakt. u. Parasitenkunde, bd. XIII, 1893, p. 457-465, figs. 7-8.

HISTORICAL REVIEW.

Natterer first discovered this parasite in *Cervus paludosus* in 1823. Only a few segments were found, and these were described by Diesing (1) under the name of *Thysanosoma actinioides*, for which he was inclined to erect a new order, *Craspedosomata*, to be placed between the

Cestodes and Trematodes. As Diesing misunderstood the nature of the animal, and mistook a single segment for the entire parasite, his description need not be reviewed.

In his Syst. Helm. (3) Diesing, having received complete specimens from Natterer, recognized that the animal was a tapeworm. He renamed the parasite *Tania fimbriata* and gave as diagnosis:

Caput obtuse tetragonum magnum, acetabulis hemisphaericis angularibus anticis. Collum nullum. Corpus antrorsum lanceolatum, articulis cuneatis brevissimis, superiorum margine postico integerrimo, subsequentium crenato, ultimorum utrinque fimbriato. Aperturæ genitalium—. Long. 6'''-6''; lat. 1-3'''.

In his third publication (4) he gives substantially the same diagnosis, adding "*articuli maturi soluti 1''' longi, 2''' lati, fimbriis lanceolatis.*"

Siebold's remarks (5) are simply of an historical nature.

The next article at my disposal is by Faville (6), who found tapeworms in sheep in Colorado. The worms were found in the gall-ducts and in the intestines. He includes all the worms under the name *Tania expansa*, but there can be little doubt that the worms he found in the gall-ducts were *Th. actinioides*, while the worms he describes as 5 or 6 feet long must belong to some other species.

Curtice (7) had occasion to investigate a *Tania fimbriata* epizootic in Colorado in 1886 and 1887. He states that the adult specimens are 15-30^{cm} long by 8^{mm} wide. The broadest portion is about 2^{cm} from the posterior end. Head is 1-1.5^{mm} wide. Genital pores double. The segments attain maturity about the middle of the worm. The male organs develop first, and occupy the entire breadth of the young segments. The uteri develop last. Each uterus is composed of a series of bags, arranged side by side in a fringe, which extends along the anterior edge of the segment. The bags empty into a tube which is connected with the ovaries. The worms are found in the gall-ducts and duodenum. Curtice found one specimen in a lamb 2 months old, but he states that yearlings and 2-year olds are more infested than lambs. The worm requires six to ten months for its development. Curtice's experiments for direct development without change of host were negative. He further discusses the geographical distribution and treatment. He also refers to an article by Stewart. The reference is, however, incorrect and it has been impossible to trace the paper. Curtice reprints his observations in his report on the animal parasites of sheep (8).

Neumann (9) evidently takes his diagnosis from Curtice.

Stiles (10) remarks upon the anatomy and reestablishes the genus *Thysanosoma*.

Besides the above articles this species is mentioned in several places, but no new facts are given in regard to its anatomy or life history.

Specific name.—According to the rules of nomenclature, the specific name given to a fragment of an animal must hold for the entire animal in case the fragment was named first. Hence nothing remains in this case but to accept the specific name *actinioides*. In separating this worm, together with *T. Giardi*, from the genera *Moniezia* and *Taenia*

s. st., it is necessary to accept the generic name *Thysanosoma* instead of creating a new name.

Considerable material is at hand which Curtice collected in 1886; it is, however, very poorly preserved, so that there are a number of points in regard to the structure of the parasite which it has been found necessary to omit.

ANATOMY.

The scolex.—The head (Plate XI, Figs 2, 2b) measures 1–1.5^{mm} wide; it is very prominent, much broader (almost square when viewed *en face*) than long, so that it looks almost like a crosspiece placed upon the anterior end of the strobila. The four suckers are very powerful, separated from each other by deep depressions (in other words, the suckers are prominently raised); each sucker measures about 0.48^{mm} in diameter; the opening is circular or slightly oval, and is directed half anteriorly at the four corners of the head. The scolex is quite sharply defined from the neck (Plate XI, Figs. 2, 2a), which measures about 0.9^{mm} broad and is very flat. The unsegmented portion is very short, or almost absent; 0.48^{mm} from the head the segmentation is quite distinct, while at about 1.5 from the head the posterior edge of the segments show short prolongations, which increase gradually in length as the segments grow older, forming the fimbriae, so characteristic of this species.

Segments 20^{mm} from the head measure 2.4^{mm} wide by 0.24^{mm} long. No internal organs could be distinguished. No interproglottidal glands are present. The posterior edge of the segments is about 0.25^{mm} broader than the anterior edge; the flap extends over the anterior edge of the next following segment by 48 μ , and is divided into about 70 lobes which form a fringe work around the entire segment.

Segments 40^{mm} from the head measure 2.7^{mm} broad by 0.32^{mm} long. A genital anlage becomes visible on each side of the segment, just median of the longitudinal canals.

Segments 60^{mm} from the head (Plate XI, Fig. 3) measure 3.2^{mm} wide by 0.35^{mm} long; the fringe is somewhat longer in the median line (0.16) than on the edge (0.032).

In segments 80^{mm} from the head the genital anlage has extended into the lateral field towards the posterior half of the edge. The anlagen of the male and the female canals gradually separate from each other. The fringe on the posterior edge increases in length.

Segments 100^{mm} from the head (Plate XI, Fig 4) measure 4.8^{mm} wide by 0.35^{mm} long. The pores have pierced in the posterior half of the lateral margin. The male and female canals can be distinguished from each other. Just median of the longitudinal canals the vagina ends in a clump of tissue in which it was impossible to distinguish any differentiation into ovary, etc.; the vas deferens forms a number of convolutions; the posterior portion of the median field of every segment is occupied by the testicles, which generally appear slightly less numerous in the median line than elsewhere.

Segments 120^{mm} from the head measure 5.1^{mm} wide by 0.36^{mm} long. The vagina and cirrus are very long, thin, and distinct; copulation occurs in these segments. Fig. 7 represents the penis in copulation; the genital pore is closed by contraction; the cirrus is inserted into the vagina.

Unfortunately, the material at hand is so poor that an exact description of many interesting points in connection with this species must be omitted for the present, and as *Th. actinioides* is rarely found in this part of the country, it is doubtful when a complete account of the anatomy can be given. The following points could, however, be established:

The genital canals pass between the longitudinal canals, as in *Th. Giardi*. The inverted cirrus and the vas deferens are quite convoluted, the cirrus-pouch long; the testicles are confined to the posterior half of the median field. The vagina generally passes on the dorsal side of the proximal portion of the cirrus-pouch, but the position of the vulva could be distinguished with less certainty; in many (all?) cases it is situated *anterior* to the cirrus in nearly the same frontal plane. As the vagina passes into the median field (Fig. 6) it runs ventrally across the convolutions of the vas deferens, which tend towards the dorsal surface. The ovaries, etc., lie just median of the longitudinal canals, but the topography of the various canals can not be given. Only a single uterus (Fig. 8) is present in each segment. This is like the uterus of *Th. Giardi*, and so far as observed it develops in the same manner.

The ventral canals are lateral and run parallel to the nerves; the smaller canals lie somewhat median of the lacunes, and are distinctly dorsal. At the posterior border of each segment there are two small (Fig. 5) but distinct transverse canals; the ventral transverse canal connects the lacunes (ventral longitudinal canals); the dorsal transverse canal connects the dorsal longitudinal canals. In connection with the double transverse canals it is worthy of note that the dorsal canal is not so rudimentary as in the other species described in this paper. From both dorsal and ventral transverse canals a system of extremely minute irregularly branching canals could be traced into the parenchyma of the segment.

Segments 140^{mm} from the head measure 5.1^{mm} wide by 0.4^{mm} long. The fimbriae are about as long as the segment. Segments 170^{mm} from the head measure 5.1^{mm} wide by 0.4^{mm} long. Some of the fimbriae are 0.4^{mm} long.

SPECIFIC DIAGNOSIS.

The following is given as a specific diagnosis of this form:

Thysanosomea actinioides Dies., 1834.—Strobila 15–30^{cm} long; head large, nearly square when viewed *en face*, 1–1.5^{mm} broad, placed like a T on the neck. Suckers very large, prominent; openings large, elongated or oval, at the four corners, and directed forward or half forward. Neck is exceedingly flat dorso-ventrally, and quite broad. Segmentation begins almost immediately back of the head. The

broadest segments measure 5-8^{mm} wide by 0.4-0.6^{mm} long, and are situated about 2^{cm} from the posterior end. The posterior segments show a decided tendency to become longer and narrower. Mature segments attain a thickness of 2.2^{mm}. The posterior flap of the segments is broken up into fimbriae, which in the end segments attain the length of the segment itself. There are present in each segment two lateral genital pores, two ovaries, two vitellogene glands, but only one uterus. The latter is situated in the anterior portion of the median field, is composed of a small canal with numerous blind sacs, and surrounded by a thick fibrous tissue. The genital canals pass from the median field between the dorsal and ventral canals and dorsally of the nerve. The dorsal canals are somewhat smaller than the ventral canals and connected by transverse segmental canals. Ova measure $\frac{1}{2}$ in diameter; horns of pyriform body not developed. (No ova at my disposal).

Typical specimens in the Bureau of Animal Industry. Specimens will be sent to museums and specialists exchanging with this Bureau.

C. W. S.

(10) *Thysanosoma Giardi* (Riv., 1878) Stiles, 1893.

[Plates VII Fig. 5, XII, XIII.]

Synonymy.—*Tania ovilla* Rivolta, 1878; *Tania Giardi* Moniez, 1879; *Tania aculeata* Perroncito, 1882; *Moniezia ovilla* (Riv., Mon.) Moniez, 1891; *Moniezia ovilla* var. *macilenta* Moniez, 1891; *Thysanosoma Giardi* (Riv., Mon.) Stiles, 1893.

Hosts.—Sheep (Rivolta, Macerta, Moniez, Stiles); cattle (Perroncito, after Riv.).

Geographical distribution.—Italy (Rivolta, Perroncito, Macerta); Germany (R. Leuckart, at Leipsic); France (Moniez, at Lille; Stiles, at Paris). Not reported in America up to date.

LITERATURE.

- (1) RIVOLTA. Di una nuova specie di *Tania* nella pecora, *T. ovilla*; Giorn. Anat. Fisiol. e Patolog. degli Animali, Pisa, 1878, pp. 302-308, 3 figs.; (also, in Studi fatti nel Gabin. di Anat. patolog. di Pisa, 1879, p. 79, 3 figs.).
- (2) MONIEZ. Sur le *Tania Giardi* et sur quelques espèces du groupe des inermes; Comptes rendus de l'Acad. d. Sc., 26 mai, 1879, pp. 1094-1096.
- (3) PERRONCITO. I Parassiti, etc., Milano, 1882 (pp. 244-246, *T. ovilla*; pp. 246-247, *T. aculeata*).
- (4) MONIEZ. Sur quelques types de Cestodes; Comp. rend. d. l'Acad. d. Sc., 6 Mars., 1882, p. 662 (*T. Giardi*).
- (5) ZERN. Die tierischen Parasiten, Weimar, 1882 (pp. 198-199, *T. ovilla*).
- (6) RAILLIET. Éléments de Zoologie médicale et agricole, Paris, 1886 (p. 261, *T. aculeata*; p. 264, *T. Giardi*).
- (7) PERRONCITO. Trattato teorico-pratico sulle Malattie più comuni degli Animali domestici, Torino, 1886 (pp. 236-237, *T. ovilla*; pp. 237-238, *T. aculeata*).
- (8) NEUMANN. Traité des maladies parasitaires non-microbiennes, Paris, 1888 (p. 383, *T. aculeata*, *T. ovilla*, *T. Giardi*).
- (9) MONIEZ. Les Parasites de l'Homme, Paris, 1889, (pp. 123-124, *T. Giardi*).
- (10) NEUMANN. Observations sur les Ténias du Mouton; Comp. rend. d. l. Soc. d'Hist. Nat. d. Toulouse, 1891, 10 fev., 4 pages (*T. ovilla*).
- (11) MONIEZ. Notes sur les Helminthes; Rev. Biolog. du Nord d. l., France, 1891, T. IV, Oct. (*Moniezia ovilla*, *M. ovilla* var. *macilenta*).
- (12) BLANCHARD. Notices helminthologiques, 2 sér. 7; Mém. d. l. Soc. Zool. d., France, 1891, pp. 443-446 (*T. ovilla*).
- (13) NEUMANN. Traité, etc., 2 éd., 1892, pp. 408-409, 410; figs. 195-196, *T. ovilla*.—English translation by Fleming, London, 1892, pp. 419-421.
- (14) ——— Sur la place du *Tania ovilla* Riv. dans la Classification; Comp. rend. d. l. Soc. d'Hist. Nat. d. Toulouse, 2 mars, 1892, 3 pages.

- (15) STILES. Notes sur les Parasites—13: Sur le *Tenia Giardi*; Comp. rend. d. l. Soc. d. Biol., Paris, 1892, pp. 664-665.
 (16) ——— Bemerkungen über Parasiten—17: Ueber die topographische Anatomie des Gefässsystems in der Familie *Teniada*; Centralblatt f. Bakt.u. Par., 1893, bd. XIII, p. 457-465, figs. 5-6.

HISTORICAL REVIEW.

Prof. Rivolta, of Italy, (1) seems to be the first person who noticed that this tapeworm differs from *M. expansa*, so frequently found in sheep, deer, cattle, etc. In 1874, while working on cestodes, he came across a peculiar form, which he decided did not belong to the species *T. expansa*, and which scarcely agreed with the species *T. denticulata*. He labeled the worm "*T. denticulata?*". Four years afterward he saw a parasite which Perroncito found in an ox and which he (R.) immediately recognized as identical with the form he had found in 1874 and labeled "*T. denticulata?*". Rivolta gave a very good description (1) of the worm, identifying most of the anatomical structures; he gave two figures of the parasite, which are easily recognizable, although unfortunately (evidently by a mistake of the editor rather than the author), the segments are turned upside down. For this new species Rivolta proposed the name *T. ovilla*.

Rivolta clearly recognized that the genital pores and ovaries were irregularly alternate; also that the testicles were placed laterally of the longitudinal canals. His description of the uterus is also quite exact. Rivolta's second paper (1879) is not at my disposal.

A year after Rivolta's publication Prof. R. Moniez (2), of Lille, France, described a tapeworm of sheep as a new species, to which he gave the name *Tenia Giardi*. He distinguished two ovaries in each segment, as is plainly seen from his statement that "Two of them (*i. e.*, currents of spermatozoa) are lost in the *neighboring ovary*;* the third extends across the segment and fecundates the *ovary** of the *other side*."*

Perroncito (3, 7) next mentioned *T. ovilla* in 1882 and 1886, adding nothing, however, to Rivolta's description. He also described as a new species (3, pp. 246-247) *Tenia aculeata*, which he considered as "very closely allied to, if not identical with, *T. ovilla*."

Moniez (4) then mentioned *T. Giardi* again, but added scarcely anything new to his original description. In his book on the parasites of man (9) he states that the eggs of *T. Giardi* are arranged in bundles of 15-30 each, very similar to the egg bundles of *Tenia madagascariensis*.

Railliet (6) considered *T. ovilla* Riv. and *T. aculeata* Per. identical, and accepted the specific name *T. aculeata*, since *T. ovilla* had previously been used by Gmelin.

Neumann (10) then obtained type specimens of *T. ovilla*, *T. Giardi*, and *T. aculeata*, and decided that all three parasites belonged to one species,

* The italics do not exist in the original.

for which he accepted the name *T. ovilla*. A point which it is important to note is that Prof. Neumann states very decidedly that only one genital pore is present in each segment.

Since Neumann's paper appeared Moniez (11) has again written on this parasite. In this last paper he adopts the synonymy given by Neumann, and again asserts in most positive terms that double genital pores are present, and on this account he places the worm in Blanchard's new genus *Moniczia* (*M. ovilla*). ("Je me suis récemment encore assuré de son existence de la façon la plus certaine.") In the same paper Moniez describes as a new variety of sheep-tapeworm under the name *Moniczia ovilla* var. *macilenta*, a form in which the egg-shells are small and the strobila is very thin.

R. Blanchard (12) has also recently published a paper in which he speaks of *T. ovilla*, and in which he states very positively that double genital pores were found in a specimen of *T. aculeata* forwarded by Peroncito, and of *T. Giardi* forwarded by Moniez (the specimen coming through the hands of Neumann).

At a meeting of the Washington Biological Society (April 16, 1892), the writer presented a paper on "*Tenia ovilla* and its relation to Blanchard's classification." In that paper, of which only an abstract (15) appeared in print, but which is substantially the same as the present paper, an attempt was made to harmonize the contradictory statements of the authors above reviewed. Since that date Prof. Neumann has sent me a reprint of a paper (14) presented him before the "Société d'Histoire Naturelle de Toulouse," and also a personal letter in which he reiterates the statements of his former papers.

Prof. Leuckart has also stated (personal correspondence) that a *T. ovilla*, with alternate genital pores, has recently been found in Leipsic, and Prof. Moniez has written (personal correspondence) in regard to the form in which he found the double genital pores.

When two experts like Blanchard and Moniez state that they have found double genital pores in *Tenia Giardi*, their statements must be accepted. Likewise, when Rivolta and Neumann state that they found alternate genital pores in *Tenia ovilla*, their statements must also be accepted, and we must try to harmonize the two opposing views. Two alternatives are open to us, *i. e.*, we can assume that some of the segments of *T. Giardi* have only one pore while the others have two pores, or that the forms examined represent two species. As will be seen by the text and figures given below, the former alternative is the correct one.*

* Since writing the above review, both Neumann and I have examined one of Moniez's slides which appeared to present two pores in one segment. Neumann, Moniez, and I now agree that in this particular slide the section is diagonal and intersects two segments. Thus this preparation does not prove that Moniez saw two pores. However, it seems to me highly probable that he saw double pores in some other specimen.—C. W. S.

Specific name.—The specific name *ovilla* must of course be dropped, for Railliet has already pointed out that *ovilla* was used by Gmelin* to designate another worm. Moniez's specific name *Giardi* must be accepted, since Neumann has demonstrated that this parasite is identical with *T. ovilla* Riv., and since the name *Giardi* antedates *aculeata* Per. The parasite certainly can not be united in one genus with such forms as *T. saginata*, nor can it be placed in the genus *Moniezia*. As shown below, it bears very close relations to *Thysanosoma actinioides*, and accordingly these two worms are placed in one genus.

ANATOMY.

The material studied was collected at one of the Paris abattoirs in the spring of 1891: The results harmonize perfectly with the statements of Rivolta and Neumann, in that as a rule the testicles of *Th. Giardi* are lateral and the genital pores are irregularly alternate. This rule, however, has two very important exceptions, *i. e.*, first, segments are not infrequently found in which double genital pores are present (hence the statements of Moniez and Blanchard); secondly, in some segments the testicles are not confined to the lateral spaces, but are also found in the median field, *i. e.*, in the space between the lateral canals.

Prof. Rivolta gives the total length of *T. ovilla* as 1.50^m; Perroncito's specimens of *T. aculeata* measured 2^m. I have examined a large number of segments, but no complete worm; the longest strobila was 1.20^m. The form of the segments varies greatly in different specimens, and according to the state of contraction there is considerable difference in the form of the segments of the same strobila, even when the segments are in the same stage of development. Plate XII, Fig. 1, represents a strobila about 1.20^m in length. It will be noticed that most of the segments are broader than long, while the end segments are slightly longer than broad. In the third and fourth portions it will be noticed that the lateral margins are irregular, owing to a slight lengthening of one side and the projection of the genital pore. This is an appearance which is frequent, though not constant. It is confined to the segments which are not full of eggs. Plate XII, Fig. 1a, represents segments in a stage corresponding to the last portion of Plate XII, Fig. 1. All the segments are broader than long, but the last segments show a tendency to grow narrower and longer, the same as in Plate XII, Fig. 1. The segments never attain any very great thickness; the anterior proglottids are quite thin. Plate XII, Fig. 7, gives a sagittal section of a mature segment. It measured 6^{mm} wide by 1.3^{mm} long by 0.19^{mm} thick. It will be noticed that the posterior edge of one segment overlaps the anterior edge of the one next following by about 96 μ .

* Linné's *Systema naturae*, p. 3061. "*Tania ovilla*, 20. *T. ovis arietis* Goeze, *Eingew.*, p. 257."

Among the French tapeworms examined not a single head was noticed which could be positively identified as belonging to *Th. Giardi*. Two heads were found in a bottle containing segments of *Th. Giardi* and *M. expansa*, and it is probable that one of these heads belongs to the species now under consideration.

Perroncito (3, p. 246) describes the scolex of *T. aculeata* as follows:

Testa depressa, quadrangolare, col lato maggiore di millimetri 0.560-0.589, col lato minore di millim. 0.250-0.300, lunga millim. 0.500; ventose rivolte in fuori, divise da una depressione, del diametro longitudinale di millim. 0.256-0.264, trasversale di millim. 0.200-0.208. Collo breve rappresentato da un restringimento o collareto del diametro di millim. 0.536.

Neumann (13, p. 408) describes the head as "tétragone ayant un peu plus d'un millimetre de largeur, suivie d'un cou assez long, de largeur moitié moindre que celle de la tête."

One of the heads mentioned above agrees very nearly with the description, and is probably the head of *Th. Giardi*. It was connected with a strobila 38^{mm} in length.

The head (Plate XII, Fig. 2) is quadrate, stout, 0.506^{mm} broad, 0.33^{mm} long (from the anterior extremity to the constriction of the neck). The suckers are very strong, nearly round, with a diameter of 0.192^{mm}. The opening of the suckers in my specimen is elongated. The constriction back of the head measures 0.816^{mm}. Segmentation, at first extremely indistinct, begins at this point; 1.6^{mm} distal from this point the segmentation is very distinct. The first anlage of the genital organs is noticed about 2.25^{mm} back of the cervical constriction. At first only a small differentiation of tissue is seen in the median line of every segment; this arrangement (Plate XII, Fig. 3) continues for a distance of about 3^{mm}, when it is noticed that the anlage of every segment does not lie exactly in the median line, but slightly to the right or left of it. This diversion from the median line continues, so that 17.5^{mm} from the point where it begins the anlagen lie close to the longitudinal (lateral) canals. The oldest segment of this strobila measures 2.5^{mm} broad by 0.8^{mm} long. The genital anlage is very simple, and no traces of testicles can be seen.

Thus it is seen that this head and strobila belong to some cestode with alternate genital pores. If it is not a *T. Giardi*, it must be a new species (or *T. Vogti*??). The other head referred to agrees so closely with the head of *M. expansa*, that it is difficult to believe it can belong to *Th. Giardi*.

Plate XII, Fig. 4, represents seven young segments, each measuring 3.7^{mm} broad by 0.176^{mm} long. Six of these segments have a single anlage of genital organs, while one of the segments possesses anlagen of two sets of sexual organs, one of which is rather rudimentary. The genital pore has not yet pierced the cuticle of the margin. From about the middle of the lateral margin of each segment two curved and nearly parallel portions of tissue, which color darker than the surrounding parenchyma, extend across the longitudinal canal into the median field. The

anterior string of tissue represents the anlage of the male genital canal, and is thicker in its marginal portion than in its median portion. The posterior (distal) string is the female anlage. The marginal portion is somewhat thinner than the corresponding portion of the male string; the portion which crosses the longitudinal canals is extremely thin and, upon arriving on the median side of the canals, ends in a small knob, which later differentiates into ovarium, vitellogene glands, etc. In the third segment of the figure, both male and female organs are seen on one side; and on the other side only the male anlage is present.

The segments of Fig. 5, Plate XII, measure (balsam preparation made under pressure) 3.5^{mm} broad by 1^{mm} long (median line); occasionally the edge of the segment upon which the genital pore is situated is slightly longer than the edge of the other side, so that the strobila has a zigzag appearance. The pore is in the middle or back of the middle of the margin.

In segments such as are shown in Fig. 5, Plate XII, we have the following arrangement of the genital organs. The genital pores are irregularly alternate, sometimes protruding prominently from the edge of the segment in the form of a papilla, at other times nearly on a line with the edge.

Male organs.—The lateral fields are almost entirely occupied by the male organs: the anterior portion (of the papilla-lateral field) by the vas deferens* and cirrus-pouch, the posterior portion by the testicles. The cirrus is occasionally seen protruding from the pore, at other times lying in the cirrus-pouch. The cirrus-pouch (0.32^{mm} long) is more or less bottle-shape, varying somewhat both in size and form in the different segments. Anterior to the cirrus-pouch the vas deferens makes a number of turns, then crosses the lateral canals into the middle field, extends diagonally across the ovary toward the posterior (distal) portion of the segment, and branches; one branch extends back to the testicles of the pore side, while the other extends toward the opposite side of the segment.

On the pore side about fifty testicles are found occupying the posterior portion of the field, and on the opposite side about ninety are found, but they occupy the anterior portion of the field as well as the posterior portion. The testicles are about 0.024^{mm} in diameter; they do not all lie in one plane, but by focusing can be proven to lie in both the dorsal and ventral portion of the segment.

Female genital organs.—The vulva is situated close to the cirrus; the vagina follows the general curvature of the cirrus-pouch to a point about equidistant from the anterior and the posterior margins of the segment, where it curves, crosses between the longitudinal canals diagonally, and enters the median field. Directly median of the longitudinal canals it dilates slightly into the receptaculum seminis, at the

* Neumann incorrectly figures testicles in this portion of the field.

end of which several organs come together, but in this stage it is scarcely possible to make out their exact relations. It can, however, be seen that a canal (ascending oviduct) extends toward the anterior edge of the segment crossing the ovary and forming a triangular dilatation. The base of this triangle extends parallel to the proximal edge of the segment in both directions towards the longitudinal canals. This, it will be seen later, is the anlage of the uterus. The branched ovary is seen at the point where the vas deferens crosses the oviduct. Posterior (distal) to the receptaculum seminis and ovary is a differentiation, which will be seen later to be the anlage of the vitellogene gland.

In segments (Plate XII, Fig. 6) measuring 3.4mm broad by 0.8 long, the genital organs have increased in size, and the segments themselves are sharply defined from one another.

Plate VII, Fig. 5, shows a slightly diagrammatic drawing of the end portion of Fig. 6, Plate XII (microtome section). A small opening on the lateral margin of the segment leads into a sexual cloaca. The size of this sexual cloaca depends upon the position of the cirrus-pouch. If the cirrus-pouch is retracted into the body as in Fig. 6, Plate XII, the cloaca is quite deep, but if the cirrus protudes the cloaca becomes inverted and forms what is called the sexual papilla (see Plate XII, Fig. 5). Thus the genital cloaca and genital papilla are not constant organs, but the one (in its fullest development) depends upon the absence of the other. When the papilla is present it is nearly filled up by the cirrus-pouch; when the cloaca is present the pouch begins at the deepest point of the former. The pouch is somewhat pear-shaped; the broader portion is situated towards the anterior margin of the segment; the narrower portion is slightly curved. The pouch of Fig. 6, Plate XII, measures 0.42mm long. From the deepest point of the cloaca (highest point of the papilla) two canals extend towards the interior of the segment.

Male organs.—The anterior canal enters the tip of the pouch, in which it makes a number of irregular turns; the first portion is of nearly uniform size and provided with a lumen of 4μ , which is lined by a rather heavy cuticle. The wall of this portion is about 5μ thick. This is the cirrus or penis which is drawn into the cirrus-pouch. In one case the extruded penis was filiform, 80μ long. This canal gradually widens until the lumen measures about 25μ ; the cuticle and wall become much thinner. The end of the broad canal suddenly dilates into a large vesicula seminalis, with a lumen of 60μ . From the vesicula seminalis the vas deferens, 64μ in diameter (lumen 8μ), extends into the anterior portion of the lateral field; the thick walls contain a tissue which is probably of glandular nature (prostata). The vas deferens decreases in diameter (32μ , lumen 8μ) as it extends towards the longitudinal canals; it passes on the dorsal side of the large canal (lacune of some authors) and on the ventral side of the small canal.

After passing the longitudinal canals the vas deferens runs across the ovarium, on the dorsal side of the latter. As stated above, it branches; this branching sometimes takes place before it reaches the ovary, but more frequently not until it has passed to the median side of the latter. The epithelial nature of the vas deferens is very evident, and at times an extremely fine cuticle (a basement membrane) could be distinguished. The testicles measure about 80μ in diameter.

Female organs.—The second canal, which extends from the end of the genital cloaca, represents the vagina. In the genus *Moniezia* we saw that this vaginal canal bears a constant relation to the cirrus-pouch, for on the right side of the strobila the vaginal opening and canal are constantly on the ventral side of the pouch, while on the left side they are dorsal. There seems to be no such constant topographical arrangement of the vaginal canal in the case of *Th. Giardi*, for although in Fig. 5, Plate VII, it is situated somewhat ventrally, it is plainly posterior (distal) in several segments of Fig. 5, Plate XII, and segments have also been found in which the canal was dorsal. The total thickness of the canal at the beginning is about 28μ ; it increases gradually in thickness as it approaches the longitudinal canals, where it measures 40μ .

Zschokke states* that the vagina of *T. expansa* is composed of four layers: 1 (outside), a simple layer of circular muscular fibers; 2, a simple layer of longitudinal muscular fibers; 3, a homogeneous and brilliant tissue, and 4 (inside), a cellular membrane bearing cilia or hooks which project into the lumen of the vagina, and possibly serve in advancing the sperm cells into the receptaculum seminis.

In *Th. Giardi* I have been able to distinguish Zschokke's fourth layer very plainly, but have not been able to make out its cellular nature. The third layer is also very evident in my preparations. The first and second (outside) layers, which the eminent Swiss zoölogist describes in his excellent article on *T. expansa*, do not appear in my preparations of *Th. Giardi*. On the contrary, only one layer appears outside and that is distinctly cellular in its nature. These three layers end abruptly at the receptaculum seminis, which exhibits a distinct inner epithelial layer with a fine outer basement membrane.

Just median of the receptaculum seminis and connected with it is a small bulb in which the vitello-duct and oviduct come together; or, more properly speaking, the first portion of the oviduct extends from the calyx of the ovary toward the receptaculum seminis, on the median side of which it widens to receive the spermatozoa and vitelline matter. The ascending portion of the oviduct (not seen plainly on transverse sections, but very evident on frontal sections) then extends toward the anterior portion of the segment and empties into the uterus. The vitello-duct lies somewhat dorsally and distally of the descending oviduct, and empties into the bulb just referred to.

* Recherches sur la structure anatomique et histologique des Cestodes, p. 108.

It shows the same histology as the receptaculum seminis, and widens into a calyx around which are grouped the vitellogene cells. The gland in this stage measures about 0.16^{mm} in diameter. The cells of this organ color (in acid carmine) much darker than the cells of the surrounding parenchyma or the epithelial cells of the ducts. The descending oviduct agrees in histology with the vitello-duct, and widens also into a calyx around which the ovarian tubes are grouped.

The ascending oviduct is about 12μ thick, and consists of a simple epithelium with basement membrane. It passes dorsally of the ovarium, indenting the same, or even passing through its dorsal portion. The part of the oviduct between the ovary and the uterus is surrounded by a cellular tissue (shell-gland?) which colors about the same as the epithelium. The uterus in this stage is made up of a conglomeration of cells, but no lumen can be distinctly seen.

The *vascular system* drawn in Fig 5, Plate VII, is very instructive. Two longitudinal canals of different thickness and histological structure are seen. The external (ventral) canal presents a lumen of about 80μ , and near the posterior edge of the segment is connected with the corresponding canal of the opposite side by a transverse canal. The latter extends also into the lateral field of the segment. The lumen of the large canals (lacunes of some authors) is bordered by a fine membrane. Zschokke figures and describes a regular epithelium on the outside of this membrane, but in this species it has been impossible to recognize the epithelial nature of the neighboring cells, which seem to be exactly similar to the parenchymatic cells. These lacunes are supposed to be the ventral canals, a view which is supported in this species by the position of the genital organs—considering the female organs as ventral and the male organs as dorsal. The small longitudinal (dorsal) canals lie dorso-median of the lacunes. The diameter ($24\text{--}36\mu$) varies at different points, the canal suddenly swelling into bulbs at various distances from each other.

The structure is entirely different from that of the ventral canals. The central portion, which is about 5μ broad, appears as a lumen when examined under a low power, but when examined under high power appears to be filled with a spongy mass in which no nuclei are present (coagulated contents?). This spongy centrum is bounded on the exterior by a 2μ cuticle which colors very dark. This is followed by a tissue (3μ) which colors much more lightly; the exact nature of this tissue is not clear. Next comes a distinct layer of circular fibers, which I am rather inclined to look upon as of muscular nature.

The longitudinal nerves run on the marginal side of the large canals and on the ventral side of the genital canals. In segments 4.25^{mm} broad by 1.04^{mm} long the organs are but little changed. The testicles measure $0.064\text{--}0.08^{\text{mm}}$ in diameter; the ovary is considerably larger than in the segments described before; the uterus is much thicker and has assumed a wavy appearance.

In Fig. 8, Plate XII, where the segments have reached a breadth of 5mm and a length of 0.72mm (somewhat shorter than the segments described last, a fact to which no importance should be attached, as this can easily be due to contraction) the "waves" of the uterus have advanced so far as to form a number of irregular parallel and connected folds. This peculiar development of the uterus is entirely different from the case presented by tapeworms belonging in the series with *Tania solium*, *T. saginata*, etc. In these latter species the uterus develops lateral branches from a median stem, the median uterus not increasing in length disproportionately to the length of the segment. In the case of *Th. Giardi* the uterus lies parallel to the proximal edge of the segment; the two ends of the uterus are more or less stationary, and the uterus increases in length, totally disproportionately to the width of the segment, instead of sending off branches at right angles. The natural physical result of this growth is that the uterus lies in folds, which, in this case, assume a direction nearly parallel to the side of the segment. This mode of development of the uterus seems ample ground for separating, generically, worms of this kind from such forms as *T. solium*.

As the segments increase still further in size (Plate XIII, Fig. 2) (6mm broad by 1.04mm long) the folds of the uterus in growing larger are diverted from their position parallel to the sides and assume irregular positions; the testicles in the meantime become somewhat indistinct. In Fig. 3, Plate XIII (segments 6.5mm broad by 1.04mm long) the uterus occupies almost the entire median field, while the testicles are scarcely visible. The other sexual organs gradually atrophy.

Segments with more than one set of organs.—It has already been stated that Moniez and Blanchard have found segments with double pores, and that they believed that to be the normal condition. In Fig. 4, Plate XII, is pictured a segment with an extra male anlage. A number of segments have also been found in which an extra ovary and vitellogene gland were developed; also six segments in which double pores were present (Plate XIII, Fig. 1). One of these segments belonged to a strobila sent by Prof. Neumann. All the organs were double except the uterus, of which only one could be distinguished. With this the question as to the presence of single or double pores in *Th. Giardi* may be considered as definitely settled.

Eggs and egg-capsules.—Former authors have already stated that the eggs of *Th. Giardi* lie in capsules of fibrous tissue, each capsule containing 10–15 ova. Fig. 4, Plate XIII, shows the origin of these packages of eggs. At the top of the figure is seen a canal, which represents a portion of one of the slings of the uterus. Small blind sacs form on the side of this canal. The blind end of the sac enlarges, but still retains its communication with the uterus-stem through a narrow neck. The enlarged end is filled with eggs. The entire uterus with blind sacs is surrounded by a fibrous tissue, the layer being especially thick around the sacs.

Fig. 5, Plate XIII, represents these sacs in a further stage of development. Several eggs are seen at one end, but it is almost impossible to find the neck of the sacs. The eggs measure $20-23\mu$ in diameter, and appear to have but one shell, as Moniez stated. I refrain from discussing the matter of the pyriform body, as no fresh material is at hand and preserved material is unsatisfactory in this case. Moniez (11) states:

Il faut considérer la coque chitineuse qui revêt immédiatement l'onchosphère comme homologue de l'appareil pyriforme, puisqu'elle a la même origine. Le *Tenia orilla* se trouvant donc rattaché aussi aux Anoplocephalines par le plus important des caractères de ce groupe, par l'existence de l'appareil pyriform autour de son embryon. * * *

This is, of course, a point of great importance.

SPECIFIC DIAGNOSIS.

From the above review of former work on *Th. Giardi*, and from my own anatomical description, we can accept the following as a diagnosis of this species:

Thysanosoma Giardi (Riv., '78) Stiles, 1892.—Length 1 to 2 meters. Head quadrate, measuring (after Neumann) slightly more than 1mm ; (after Perroncito) $0.56-0.589$ (largest diameter), $0.25-0.3$ (smallest diameter), 0.5 long; (after Stiles) 0.506 broad by 0.33 long (balsam preparation). Neck (after Neumann) rather long, half as wide as the head; (after Per.) short, diameter 0.536 ; (after Stiles) absent. The most of the segments are broader than long, thin; only the posterior are longer than broad, their breadth being less than that of the segment immediately preceding. Unripe segments present a slightly zigzag appearance, owing to the projection of the side on which the genital pore is situated. Largest segments $5-6.5\text{mm}$ wide by $2-1\text{mm}$ long. Genital pores in the middle or behind the middle of the segment and generally irregularly alternate, but occasionally segments are found with double pores. Testicles generally confined to the lateral fields, though scattered testes are occasionally found in the median field. Uterus transverse, giving rise to folds, which run more or less parallel to the lateral margin, and possessing ascon-spore-like egg sacs which are surrounded by an extremely thick layer of tissue. Genital canals pass between the dorsal and ventral longitudinal canals and dorsal of nerve. Eggs $20-23\mu$ in diameter; a number are found together in small sacs of the uterus; horns of pyriform apparatus not developed.

Typical specimens with Bureau of Animal Industry and with Messrs. Neumann, Moniez, Rivolta, Leuckart, and Stiles.

THE SYSTEMATIC POSITION OF *TENIA GIARDI*.

It is evident from the above that this species can not remain in the genus *Moniezia*, since there is but one uterus present, and the topography of the genital canals, female glands and longitudinal canals is entirely different. It can not enter E. Blanchard's genus *Anoplocephala*, since the pores are irregularly alternate instead of unilateral. Neumann remarks that it approaches R. Blanchard's genus *Bertia*. This is true to a certain extent, but it is not deemed wise to place it in that genus until more is known about the position of the testicles, ovaries, etc., in *Bertia*. The occasional presence of double pores, on the other

hand, shows that *T. Giardi* has some relations either with *Moniezia* or with *Thysanosoma*, and on account of its great resemblance to *Th. actinioides* in the uterus and in the topographical anatomy it may be provisionally placed in the genus *Thysanosoma*.

GENERAL CONSIDERATIONS IN REGARD TO *Th. GIARDI* AND *Th. ACTINIOIDES*.

From the foregoing discussion of these two species it will be seen that these forms can not possibly be united with the genus *Moniezia*, since they differ from the species of that genus already studied in a number of important characters, *i. e.*, the genital canals pass between the longitudinal canals instead of dorsal of both canals; the cirrus-pouch appears to be ventral of the vagina on both sides (*Th. actinioides*), instead of alternating dorsal right, ventral left; there is but a single uterus present in each segment, and this has an entirely different structure from that of the species of *Moniezia* described above.

In *Th. actinioides* the first anlagen of the genital organs appear on both sides of the median field of every segment, while in the anterior portion of what we have above supposed to be *Th. Giardi* (Plate XII, Fig. 3) the anlage first appears in the median line and then gradually diverges towards the lateral portion of the median field. Notwithstanding these differences the two worms are much more closely allied to each other than to the species of *Moniezia* above described, and should, for the present at least, be placed in a genus together. The following revised characters for the genus are proposed:

GENERIC DIAGNOSIS.

Thysanosoma Dies., 1834 (reest. Stiles, 1893). Type species *Th. actinioides*.—Head unarmed; genital pores double or single; genital canals pass between the dorsal and ventral longitudinal canals and dorsal of nerve; only one uterus present in each segment; this uterus is transverse, waving, and forms blind egg-sacs which are surrounded by a thick layer of tissue; calcareous bodies absent from parenchyma; pyriform body of the eggs not well developed.

Th. actinioides and *Giardi* agree with each other in the relative position of the genital canals to the longitudinal canals, and in the form of the uterus. They differ from each other chiefly, however, in the position of the testicles and in the transverse canals, of which *Th. actinioides* has two, *Th. Giardi* one, to each segment.

Th. actinioides and *Th. Giardi* agree with *Tania marmotæ* in having but one uterus. They differ from *T. marmotæ* chiefly in the relative position of the dorsal longitudinal canals, which in the latter species lie ventral of the genital canals and lateral of the ventral canals, and in the structure of the uterus.

Moniez states that *Tania hyracis* possesses unilateral pores, and that the eggs are arranged in sacs. We know, however, too little about the *exact nature* of the sacs in that species as well as about the *topographical anatomy* of the other organs to determine in what genus the form belongs.

C. W. S.

(11) **Tænia marmotæ* Fröhlich, 1802.

[Plate VII, Figs. 6, 7.]

Synonymy.—*T. marmotæ* Fröhlich, 1802; *Moniezia marmotæ* (F., 1802) R. Bl., 1891.*Host*.—*Arctomys marmota*.

This species is introduced in this place for comparison, although it does not occur in cattle or sheep, because it is an important species to consider in connection with the genera *Moniezia* and *Thysanosoma*. Thanks to the kindness of Prof. R. Blanchard, I have been able to examine several specimens of *T. marmotæ*.

In the anatomy (Plate VII, Figs. 6, 7) of this species it is important to note that two pores are present in each segment. There are also two ovaries, two vitellogene glands, but only one uterus. This uterus is, however, totally different from that of *Thysanosoma*, for the branches or egg-sacs are not surrounded by the heavy layer of fibrinous tissue which is so characteristic of that genus. Furthermore, the eggs, according to Blanchard, are exactly like those of *Dipylidium latissimum* Riehm (*T. Goezei* Baird—*M. Goezei* (B) R. Bl.). In other words, the pyriform apparatus is well developed, which character does not agree with the genus *Thysanosoma*.

In *T. marmotæ* the topography of the longitudinal canals differs both from that of *Moniezia* and that of *Thysanosoma*, for the dorsal canal lies lateral of the ventral canal, and both of the canals as well as the nerve cross the genital canals ventrally, this latter character agreeing with *Moniezia*, but differing from *Thysanosoma*.

These characters seem to furnish sufficient grounds for separating the species *Tænia marmotæ* from the genus *Moniezia*, and for not placing it with the genus *Thysanosoma*. It certainly can not be united with such forms as *T. solium*, etc., on account of the transverse uterus, double pores, pyriform body, etc. It would also be impossible to place it in the genus *Dipylidium*, for it differs very greatly from *D. caninum* (*T. cucumerina* R.), which forms the type of that genus. The differences in the uterus, egg-balls, and rostellum are certainly sufficient grounds for not placing *T. marmotæ* in the same genus with *D. caninum*.

Should a new genus be established for this worm, as must undoubtedly be done, the generic diagnosis would read:

Head without hooks; segments broader than long. Each segment possesses two lateral genital pores; two ovaries and two vitellogene glands in the lateral portion of the median field; one transverse uterus with simple longitudinal branches. Dorsal canal between nerve and ventral canal; genital canals pass dorsally of longitudinal canals and nerve. Calcareous bodies absent from parenchyma. Eggs with well developed pyriform body.

Blanchard has already separated Riehm's species *Dipylidium Leuckarti*, *D. latissimum*, and *D. pectinatum* from the genus *Dipylidium*, and has placed them in the genus *Moniezia*, as *M. Leuckarti*, *M. Goezei*, and *M. pectinata*. The writer is in entire accord with Blanchard in the

*Type.†—Typical specimens with Drs. R. Blanchard, of Paris, and C. W. Stiles, of Washington, D. C.

view that these three forms can not be generically united with *D. caninum*, but he can not admit them to the genus *Moniezia* (see p. 54), since—

(1) There is but one uterus present in the segments of *D. Leuckarti* and *D. pectinatum*, while the uterus of *D. latissimum*, although evidently different from that of *D. Leuckarti* and *D. pectinatum*, is not similar to that of *Moniezia*;

(2) What is evidently the dorsal canal in *D. Leuckarti* is figured by Riehm (Studien an Cestoden, Taf. VI, 5,) as lateral of the ventral canal. Riehm's species must be restudied before a positive decision can be made, but it seems very possible that these three forms can be placed in the same genus with *T. marmotæ* by slightly altering the generic diagnosis given above.

C. W. S.

PART III.

STILESIA Railliet, 1893

(12) *Stilesia globipunctata* (Riv., 1874) Railliet, 1893.

[Plate XIV.]

Synonymy.—*T. globipunctata* Riv., 1874; *T. ovipunctata* Riv., 1874; *Stilesia globipunctata* (Riv.) Rail., 1893.

Hosts.—Sheep (Rivolta, Giles); † Cattle (See v. Linstow's Compendium.)

Geographical distribution.—Italy (Riv.); India (Giles).

LITERATURE.

- (1) RIVOLTA. Sopra alcune specie di *Tenia* della Pecora. Pisa. 1874.
- (2) PERRONCITO. I Parassiti, etc., 1882 (*T. globipunctata*, pp. 240, 241; *T. ovipunctata*, p. 241).
- (3) ———. Trattato, etc., 1886, p. 235.
- (4) RAILLIET. Éléments, etc., 1886, pp. 260, 261 (*T. globipunctata*, *T. ovipunctata*).
- (5) NEUMANN. Traité, 1888, p. 384.
- (6) ———. Observations, etc.; Compt. rend. d. l. Soc. d'Hist. nat. d. Toulouse, 1891.
- (7) ———. Traité, 2nd ed., 1892, p. 410;—Engl. Transl., p. 420.
- (8) STILES. Bemerkungen über Parasiten—17: Ueber die topographische Anatomie des Gefäßsystems in der Familie *Teniadae*; C. f. B. u. P., 1893, XIII, p. 457.
- (9) RAILLIET. Éléments, etc., 2nd ed., 1893 (MS).

HISTORICAL REVIEW.

Rivolta described *T. globipunctata* and *T. ovipunctata* in the same paper (1) in which he described *T. centripunctata*. The article is not at hand.

Perroncito (2,3) accepted both species; the following in regard to them is abstracted from his descriptions:

T. globipunctata (*globi-punteggiata*, Ital.). Head 1^{mm} in diameter; suckers directed forwards; neck absent. Length 45–60^{cm}; color white or greenish yellow, like the contents of the intestines. Ripe segments 2^{mm} wide by 0.15–0.17 long. Two spherical-uteri are present; they appear as two lateral rows of whitish globules in the middle or posterior third of the strobila. Few eggs are present, oval, 28 μ by 24 μ ; four hooks visible in the embryo.

T. ovipunctata (*ovipunteggiata*, Ital.). Head quadrangular, 0.50–0.65^{mm} broad; neck absent. Segments in sexual activity present to the naked eye two lateral lines composed of fine points, between which are seen larger bodies which are oval. This punctation is due in part to the vas deferens and in part to the uterus. The segments immediately following the head vary in breadth from 0.33–1^{mm}, with a length of 0.03; in mature segments the breadth is 1–2.5, length 0.08–0.12. Genital organs are on the sides of the segments; eggs oval, 20 μ by 16 μ .

The head of this worm buries itself in the intestinal mucosa and causes a degeneration of a number of the villi. It obstructs the function of the Lieberkühn glands to a certain extent, maintains an irritation in the cytogenic substance, giving rise to hyperplasia of the interglandular tissue, and forming nodules or elevations at those portions where the worm has fastened itself. In some places these elevations are confluent, in others isolated. Their size varies from that of a pea to a lentil, and they manifestly proceed from a circumscribed tumefaction of a fold of the mucosa.

Railliet (4) had evidently not examined the worms, but admits the two species. Neumann (5) adds that the testicles of these two species are in the lateral fields. He then (6) obtained a specimen which Rivolta had labeled "*ovi-globipunctata*." Neumann states that the two species are identical, and that the median line remains transparent. In the second edition of his *Traité* (7) he holds to the same opinion, and unites the two worms under one diagnosis.

Von Linstow includes these worms in his list of cattle parasites, and following him the writer has done the same, although unable to trace any positive authority for so doing. Later (8) I stated that a new genus would have to be created for this and the following species.

Railliet (9) establishes a new genus *Stilesia* for *T. centripunctata* and *T. globipunctata*. (Personal correspondence; the second edition of Railliet's work is in press.)

Prof. Neumann very kindly sent a number of segments labeled *Tania globipunctata* which he had received from Prof. Rivolta, and Dr. G. M. Giles, of Sanawar, Punjab, India, has forwarded a number of specimens from India. Dr. Giles writes:

The worms are very social, dozens being found coiled up in a compressed mass in the small intestine. When fresh they are beautifully transparent and delicate. They would escape notice of anyone but a regular helminthologist, although masses half the size of one's fist may occasionally be found. In the fresh state they look so much like a mass of the pulstaceous intestinal contents of this part of the intestine that the ordinary veterinarian would be pretty sure to overlook them.

I have found them in every sheep I have examined up here, but the fact that I have sometimes identified the worms as of one species, sometimes as another, makes me suspect that two or more species are present. *T. expansa* is also common in sheep out here, but not nearly so common as the delicate species. I have never found any tapeworms in the intestines of our oxen, i. e., *Bos indicus*.

It is upon these two sendings that the following description is based. Unfortunately the material was not preserved for fine microscopic work, so that the description given below is necessarily incomplete in many respects. Nevertheless, data enough are given to show that this worm is entirely different, not only specifically but also generically, from any of those described above.

ANATOMY.

General appearance.—The strobilæ in possession of this Bureau vary from 60–150^{mm} in length, but no one strobila is complete. The widest

segments are 2.5^{mm} broad, while the anterior and posterior segments are much narrower. In a fresh state they were transparent (Giles), and many of them have remained so in alcohol, while others have become more or less opaque. The head on the anterior end is quite prominent and appears like a knob. The anterior portion of the strobila is generally quite regular in outline, but the greater part of the worm is crenate and more or less twisted, thus making it quite difficult to prepare in mounts.

The head (Plate XIV, Figs. 2-2b) measures $0.768\text{--}0.9^{\text{mm}}$ in diameter. It is square when viewed *en face*. The suckers are generally quite prominent, and more or less lobed according to the state of contraction. They measure (balsam preparation) 0.336^{mm} in diameter, the muscular wall being 30μ thick. The opening is round or oval and directed in some cases anteriorly, in others more diagonally. The neck varies greatly according to contraction, in some specimens appearing to be absent; in others it is quite distinct. In one balsam preparation it measured 0.28^{mm} broad directly back of the head, and was 2.2^{mm} long. The longitudinal canals were very distinct, two lying dorsally and two ventrally, and measuring 6μ in diameter. The ventral canal was 16μ lateral of the dorsal canals. Segmentation becomes quite distinct at about 2.8^{mm} from the head. The distance between the dorsal and ventral canals gradually widens, and about 8.8^{mm} from the head irregularly alternate pistol-shaped genital anlagen appear, the handle of the pistol being situated in the space between the dorsal and ventral canals of the same side.

Segments 15^{mm} from the head (Plate XIV, Fig. 3) measure 0.56^{mm} broad by 56μ long. The longitudinal nerves were discovered in the extreme lateral portion of the segments. About 0.12^{mm} from the lateral edge near the ventral canal, provided with an extremely thin cuticle and having a diameter of 8μ ; 40μ nearer the median line was situated the dorsal canal, with a diameter of 6μ , and with a slightly heavier cuticle than that of the ventral canal. No transverse canals could be discovered connecting the dorsal canals, but near the posterior border of each segment there was a fine transverse canal running between the ventral canals. A short transverse canal also extended from each ventral canal towards the margin of the segment.

Male genital organs.—On each side of every segment are situated, between the ventral canal and the nerve, 4-7 testicles, measuring $8\text{--}9\mu$ in diameter. The genital pore is not yet present. Irregularly alternate in the anterior portion of the segment there is a clump of tissue 68μ long by $12\text{--}14\mu$ broad, which afterwards differentiates into the cirrus-pouch and the vagina.

Female genital organs.—From the posterior portion of this clump of tissue one can trace a thin string of nuclei which runs toward the longitudinal canals, crosses the ventral canal dorsally, and ends in a mass of tissue; the latter is situated between the dorsal and ventral canals,

and represents the female glands; it is composed of an anterior and a posterior portion.

Segments 27^{mm} from the head (Plate XIV, Figs. 4, 5) measure 1.14^{mm} broad by 96 μ long. The nerves have preserved their extreme lateral position and run ventrally of the genital organs. The ventral canals run about 0.18^{mm} from the lateral margin, and have a diameter of 16 μ . The dorsal canals run 0.1^{mm} nearer the median line, and have a diameter of 7 μ . The irregularly alternate genital pores have pierced in the anterior half of the margin. The genital cloaca is about 20 μ deep, and from its proximal end two canals extend toward the median line. One of these canals (the vagina) lies dorsal, the other (the cirrus) lies ventral.

Male organs.—The cirrus-pouch is rather pyriform, 56 μ long by 40 μ broad. In its distal portion is situated the inverted cirrus, 50 μ to 60 μ long by 6 μ broad. This colors very intensely, owing to the ciliated layer surrounding its lumen, and is thus quite sharply defined from the portion of the male canal which immediately follows. This latter makes a turn or two inside of the pouch, and then can be followed across the segment to the testicles of the other side. In its course it runs from the cirrus-pouch anteriorly of the testicles of the pore side, dorsally of the ventral canal and the female glands, ventrally of the dorsal canal, then running through the median field it lies anterior and dorsal of the transverse canal. It crosses the dorsal canal ventrally, the ventral canal dorsally, and is finally lost in the testicles. This vas deferens undoubtedly receives the spermatozoa from the testicles on both sides of the segment, although it was impossible to observe any fine branches running to the separate testicles of the pore-side. The testicles have increased considerably in size, and now measure 20–28 μ in diameter.

Female organs.—The vulva lies on nearly the same frontal plane as the cirrus, or somewhat dorsally. The vagina then curves so as to lie dorsally of the cirrus-pouch. Ciliary projections could be seen for about 20–52 μ from the vulva, then they became indistinct. The vagina then becomes very thin and crosses the ventral canal dorsally. At this portion it is generally somewhat convoluted. Just median of the ventral canal it increases somewhat in diameter, forming the receptaculum seminis. The median end of the latter then branches, forming two canals about 3 μ in diameter. These two canals vary in their relative position. In general, however, one of them lies ventrally of the other, and after running a very short distance (about 15 μ) toward the median line, it turns anteriorly and ends in the ovary. This canal is evidently the oviduct. The other canal extends just beyond the ovary, and is then lost to view. The ovary is a circular body 27–42 μ in diameter.

In these segments one finds the anlagen of two more female organs, *i. e.*, the uteri. On the pore-side of the segment there is a clump of small darkly staining nuclei, situated ventrally of the receptaculum

seminis and dorsally of the ovary. On the opposite side of the segment there is an anlage, which is exactly similar in appearance to the one just described.

Segments 50^{mm} from the head (Plate XIV, Figs. 4, 5) measure 1.15^{mm} broad by 96 μ long. The ovary has increased in size, now measuring 60 μ in diameter. The anlagen of the uteri have grown but little. For the next 8^{mm} a complete and rapid change (Plate XIV, Fig. 6) takes place in the appearance of the female organs. It is noticed that the ovary now begins to grow less distinct, while the uteri come more plainly into view. We should naturally expect to find a canal connecting the descending oviduct and the uteri. No such canal, however, could be distinguished connecting the ovary with the uterus on the opposite side of the segment. In three different segments the writer thought he could distinguish a canal connecting the oviduct with the uterus on the same side, but was not positive that such was really the case; this point is left to be determined by some one who can procure and fix fresh material. It seems beyond question, however, that the ova descend through the oviduct and become fertilized; then, that a portion of them enter the uterus next to the ovary, while the remainder travel across the segment and enter the uterus of the other side.

In support of this view the following observations are given: The ovary becomes smaller while the uteri become larger; ova have been seen in the oviduct; at first no ova are seen in either uterus, then they appear in the uterus on the pore-side, and at the same time a broken line of ova can be seen extending across the segment toward the opposite uterus; the latter is next observed containing ova, while no ova can be distinguished in the median field. I am forced to admit that in no one segment has it been possible to find a continuous line of ova extending across the entire median field, but by combining several segments a diagrammatic line of ova may be constructed which extends from ovarium to uterus. An interesting point in connection with this wandering of the ova across the segment is that young ova, especially those found in the median field, have no definite form, a fact which points to their being capable of amœbic motion.

In segments measuring 1.344^{mm} broad by 81 μ long, still another change takes place in the form of the female organs. The uteri of both sides elongate medio-anteriorly, the prolongation having a fibrinous appearance. The oviduct is still faintly visible, and the ovary nearly or quite devoid of eggs can be distinguished on the ventral side of the uterus of the pore-side. At the same time another organ, the function of which I am unable to explain, appears anterior to the uteri and running transversely. This organ lies ventrally of the vas deferens—in those cases where the vas deferens extends so near the anterior margin—and stains quite dark in carmine or hæmatoxylin. The exact histology of this peculiar organ could not be definitely determined. In

older segments the portion found in the median field looked very much like a canal.

In segments 1.256^{mm} broad by 0.144 long each uterus is composed of two distinct portions, a posterior-lateral bulb, 96 μ in diameter, containing the eggs which have now segmented and are surrounded by a shell, and an anterior median fibrinous prolongation 0.144^{mm} long by 72 μ broad at the base. The anterior extremity of this prolongation fits into (or connects with ??) the curve formed by the organ directly in front of it. This latter has increased considerably in size, and now extends partially around the uterus, crosses the dorsal canal ventrally, and tapers off into a fine point which runs through the median field to meet the corresponding organ of the opposite side. In one or two segments this crossed the dorsal canal dorsally instead of ventrally. The vas deferens which crosses the median field comes very plainly into view.

In segments 2.4^{mm} wide by 0.114^{mm} long the median prolongation of the uterus has partially constricted from the rest, so that we now find three more or less distinct portions of the uterus, *i. e.*, the lateral bulb containing eggs and two spherical fibrinous portions. The middle portion lies nearer the ventral surface of the worm than either the lateral or the median portion. In different segments (Plate XIV, Figs. 7-9) these three divisions of the uterus present quite different relations to each other, but the exact order of the changes can not be given, as these variations were seen on loose segments and not on a complete worm. In the segments in which these changes are taking place the vagina is greatly enlarged.

As the segments grow older they become narrower and longer; the uteri assume a more antero-posterior position; the median anterior portion of the same becomes less distinct, and ova appear in the middle portion. The transverse organ in front of the uterus has united with the corresponding organ of the other side; the testicles become indistinct. Some of the oldest segments (Plate XIV, Fig. 9) of Dr. Giles' material measured 0.624^{mm} broad by 0.28^{mm} long.

In many segments one sees at the posterior edge, especially in the lateral fields, a row of small (4-8 μ) round or oval bodies which stain very dark in hæmatoxylin or carmine. These same bodies are occasionally met with in the median field, but their presence is extremely irregular. In general appearance they resemble, to a certain extent, the calcareous bodies found in *T. crassicolis*, *T. solium*, etc. In hæmatoxylin their margin and center stain very dark, while a lightly staining zone separates the two more darkly staining portions.

Eggs.—The eggs are round or oval, and measure 14-16 μ x 10-14 μ . Only one egg-shell could be discovered with certainty, although it occasionally appeared as if two were present; at two opposite poles this egg-shell bears a spinous projection 4-6 μ long. Comparatively few ova (10-30) are found in each uterus.

SPECIFIC DIAGNOSIS.

The following is given as a provisional diagnosis of this species:

Stilesia globipunctata (Riv., 1874) Rail., 1893.—Strobila transparent, whitish or greyish yellow, 45–60^m long, very thin and not over 2.5^{mm} broad. Head quadrate 0.5–1^{mm} broad, suckers more or less distinctly lobed, opening round or oval and directed anteriorly or obliquely. Neck present, 2^{mm} or more long (neck absent according to other observers). Developing segments 0.33–2.5^{mm} broad by 0.05–0.17^{mm} long; end segments narrower and longer (0.6 by 0.28). Genital pores irregularly alternate in anterior half of lateral margin. Cirrus-pouch slightly ventral of vagina, dorsal of nerve; vas deferens crosses the ventral canal dorsally, the dorsal canal ventrally; testicles in both lateral fields. Vulva on about the same frontal plane as cirrus; vagina generally dorsal of cirrus-pouch, crosses the ventral canal dorsally; ovary between the longitudinal canals on pore side of segment; two uteri present in each segment, one on each side and situated dorsally of ovarium; each uterus may be more or less distinctly divided into 3 globular bodies; a transverse organ of undetermined function anterior of uterus. At posterior border of lateral field is found a line of round or oval, refringent, chromatophil particles, 4–8 μ in diameter. Ova 14–16 μ by 10–14 μ . Single shell with a spinous prolongation 4–6 μ long at two opposite poles.

Type with Prof. Rivolta; typical specimens in Bureau of Animal Industry and collection of Stiles, at Washington; in collection of Leidy, at Philadelphia; and with Prof. Neumann, Toulouse, France.

It may be well to call attention to the following points, which should be more definitely determined by someone who is able to obtain perfectly fresh material: (1) What is the nature of the transverse organ anterior to the uterus? (2) Is there a canal extending from the descending oviduct to the uteri, or do the ova gain access to the latter by amœbic motion through the tissue? (3) What is the exact order of the changes in the form of the uterus? (4) What is the function of the canal which joins with the oviduct at the ovarium; do the ova pass through this canal to the median field? C. W. S.

(13) *Stilesia centripunctata* (Riv., 1874) Railliet, 1893 MS.

[Plate XV, Figs. 1–6.]

Synonymy.—*Tania centripunctata* Rivolta, 1874; *T. centripuncteggiata* (R.) Perr., 1882 (Italian); *Stilesia centripunctata* (Riv.) Rail., 1893.

Hosts.—Sheep (Riv., Mattozzi); ? Cattle (after ? see v. Linstow's Compendium).

Geographical distribution.—Italy (Riv. Mattozzi); Algeria (Neumann's specimens).

LITERATURE.

- (1) RIVOLTA. Sopra alcune specie di Tenie della Pecora. Pisa. 1874.
- (2) PERRONCITO. I Parassiti, etc., 1884, p. 242.
- (3) ———. Trattato, etc., 1886, pp. 235, 236.
- (4) RAILLIET. Éléments, etc., 1886, p. 261.
- (5) NEUMANN. Traité, 1 ed., p. 383.
- (6) ———. Observations sur les Ténias du Mouton; Compt. rend. d. l. Soc. d'Hist. Nat., 1891. 18 Mars.
- (7) ———. Traité, 2 ed., 1892, p. 409, fig. 197. Eng. Transl., p. 419.
- (8) RAILLIET. Éléments, etc., 2 ed. 1893.

HISTORICAL REVIEW.

This parasite was first described by Rivolta (1) in 1874. The original article is not accessible. Perroncito (2,3) says in regard to it that the head (scolex) measures 2^{mm} ; suckers are large; neck entirely absent; the strobila measures $2.75\text{--}2.84^{\text{m}}$ long, wider in the anterior half than in the posterior half; 10^{cm} from the head the proglottids are $2\text{--}4^{\text{mm}}$ wide; 50^{cm} from the head they measure $2\text{--}3^{\text{mm}}$ wide; 150^{cm} from the head they measure 1.5^{mm} wide; at the end of the strobila they are scarcely 1^{mm} wide. They are quite thick, the thickness increasing as the segments grow older.

The mature specimens (preserved) were yellowish white and almost round. In the center of each segment, beginning at about the middle of the strobila, a round or elliptical and rather prominent spot could be noticed by the naked eye. This prominence increases in the posterior segments, alternates on the two surfaces, and is formed by the female organs in the center of the proglottid. The testicles are situated laterally in each segment; a single genital pore is present in each segment, situated in the middle of the lateral margin. Eggs are spherical with a single shell, diameters $22\text{--}24\mu$ by $21\text{--}22\mu$; six hooks in protoscolex; very few ova present in each proglottid. Rivolta found these worms in the small intestines of a sheep. The mucosa was in part reddish, owing to hyperæmia of the villi, and in part pale and grayish on account of the pigmental degeneration of the villi. Dr. Mattozzi noticed only a catarrhal affection in the intestines of sheep infested with this parasite.

Raillet (4) takes his diagnosis from Rivolta or Perroncito, and has evidently not seen the parasite in question.

Neumann (5) does not state that he had examined the worms, but adds to Raillet's diagnosis that the length of the segment is $\frac{1}{16}\text{--}\frac{1}{8}^{\text{mm}}$, increasing with the age of the segments; the testicles are in the lateral portion of the median field; pores irregularly alternate.

Neumann (6) obtained several specimens from Algeria and adds to the foregoing that there are from 1,800 to 2,200 segments in each strobila. In the second edition of his *Traité* (7) he gives a figure of the head.

v. Linstow in his compendium places this species among the parasites of cattle. Following v. Linstow I also placed it in the Check-list of Animal Parasites of Cattle (Note 8), recently published, although I have been unable to ascertain when, where, or by whom it has been found in cattle.

ANATOMY.

Through the extreme kindness of Prof. Neumann I am in possession of a specimen which he obtained from Algeria, and although, as this French savant wrote, the strobila is not well preserved, the anatomy of this species will be described below as fully as the mate-

rial allows. The scolex of the specimen is too contracted to warrant any statements (cf. Plate xv, Figs. 2-2b).

In a portion of the strobila measuring 1.04^{mm} broad (Fig. 3) a darkly coloring tissue occupied the median line; on each side of this was a clear space; lateral from these spaces testicles were visible; then a clear space—a longitudinal canal; lateral of this there is another longitudinal line (nerve?).

In a portion of the strobila measuring 1.12^{mm} wide (Plate xv, Fig. 4), instead of having a dark tissue on the median line, this portion of the field was clear for a space 0.16 broad. At the border of this field were found clumps of darkly stained tissue, irregularly alternate. These represent the handle of the pistol-shape genital anlagen; the muzzle of the pistol can be traced almost to the lateral edge of the strobila; further, it could be plainly seen that the testicles were situated not only on the median side of the longitudinal canals, but also dorsally (? or ventrally) and laterally of them.

The testicles measure 64 μ in diameter (preparation was subject to pressure while coloring). In the strobila, measuring 1.24^{mm} broad (Plate xv, Fig. 5), it is noticed that a line of deeply stained tissue runs from the handle of the pistol a short distance towards the opposite side of the segment; the lateral portion of the analage of the canals (muzzle of the pistol) is quite thick and partially differentiated into two parts (male and female). Where the strobila was 1.6^{mm} wide (Plate xv, Fig. 6) the borders between the segments could be distinguished; the segments varied from 32 μ long on the side without the pore to 64 μ long on the side with the pore. The median portion (0.24^{mm} broad) of the median field is now entirely occupied by the dark tissue referred to above as running from the handle of the pistol towards the other side of the strobila (probably uterus).

With the material at hand I do not feel justified in making any further statements.

SPECIFIC DIAGNOSIS.

The following is given as the diagnosis of this species:

Stilesia centripunctata (Riv., 1874) Rail., 1893. (*Provisional*).—Head large, 1.5-2^{mm} broad, suckers large, directed anteriorly (after Neumann), situated at the four corners, directed diagonally forward (after Stiles). Strobila attains nearly 3^m in length. Segments 10^{cm} from the head measure 2-3^{mm} wide, and from this point they grow narrower; posterior segments measure scarcely 1^{mm}; always much broader than long, and longer on the pore side than on the opposite side. Genital pores irregularly alternate. Transverse uterus in the median portion of the median field. Testicles extend from each end of the uterus to the lateral (?) nerve. Eggs spherical with a single shell without pyriform apparatus; diameter 20-24 μ by 21-22 μ .

Type with Prof. Rivolta. Typical specimens with L. G. Neumann, Toulouse, Bureau of Animal Industry, and C. W. Stiles, Washington, D. C.

GENERAL REMARKS IN REGARD TO *STILESIA GLOBIPUNCTATA* AND
STILESIA CENTRIPUNCTATA.

From the above description of these two species, although the account of *S. centripunctata* is very incomplete, it is evident that these forms can not be generically united with *Moniezia* or *Thysanosoma*. They differ from both of these genera in the form of the uterus and the general arrangement of the genitalia. *S. globipunctata* agrees with *Thysanosoma* in the relation of the genital canals to the nerves and longitudinal canals. This relation could not be definitely determined for *S. centripunctata*.

A new genus must certainly be established for *T. globipunctata*, and although *T. centripunctata* agrees with this form in comparatively few characters—narrow strobila, short segments, irregularly alternate pores, absence of testicles from median portion of median field, size of egg and single egg-shell—it will probably be better to place the two forms in one genus until *T. centripunctata* can be more thoroughly studied. Railliet has also recognized the necessity of establishing a new genus for these forms, and has proposed the generic name *Stilesia* (*S. globipunctata* and *S. centripunctata*). The following will suffice for a provisional diagnosis until *T. centripunctata* can be thoroughly studied:

GENERIC DIAGNOSIS.

Stilesia Railliet, 1893.—Type species *S. globipunctata* (Riv.) Railliet, 1893. Head with four suckers but no hooks. Strobila thin and narrow. Genital pores irregularly alternate. Segments broader than long. Two distinct sets of testicles present in each segment, one on each side, but no testicles in the median line. Eggs very small (not over $24\ \mu$) and with but one shell.

The following points, which may prove to be of generic value, have been established only for *S. globipunctata*: Genital canals pass dorsally of nerve and ventral canal, but ventrally of dorsal canal. Egg-shell with two conical spinous projections at opposite poles.

Habitat.—Intestine of sheep. Development unknown.

C. W. S.

PART IV.
SPECIES INQUIRENDÆ.

(14) *Moniezia nullicollis* Moniez, 1891.

[Plate XVI, 3-3b.]

Host.—Sheep (Moniez).

Geographical distribution.—Thus far *M. nullicollis* has been reported only at Lille, France, by Prof. R. Moniez.

LITERATURE.

MONIEZ. Notes sur les Helminthes VI, 3; Revue Biologique du Nord de la France, T. IV, 1891, 1 page.

HISTORICAL REVIEW.

Prof. Moniez found two specimens of tapeworms at the Lille abattoir in May, 1879. In 1891 he described them as a new species under the name given above, giving, however, only a very short description. He states that the worms were 40^{cm} long. The last segments were perfectly mature and measured, in alcohol, 8^{mm} wide by 1^{mm} long. They were quite thin and all the segments very short. Head cuboid, rounded in front, hemispherical in back, 1.3 in diameter. Suckers 0.65 in diameter. Neck absent, so that the segments begin directly back of the suckers. Ova 55-65 μ ; embryo 21 μ .

At my request Prof. Moniez forwarded part of his original material. I have only the head (Figs. 3-3b, Plate XVI), and hence can give no statements in regard to the anatomy of the segments.

DIAGNOSIS.

It is impossible to give a satisfactory diagnosis of this form, hence I can not as yet look upon it as a well-established species.

Type with Prof. Moniez. One scolex in private collection of C. W. Stiles, Washington, D. C. C. W. S.

(15) * *Tænia Vogti* Moniez, 1879.

Synonymy.—*Tænia Vogti*, Moniez, 1879; *Anoplocephala Vogti* Moniez, 1891.

Host.—Sheep (Moniez).

Geographical distribution.—France (at Lille, Moniez).

* Type specimen is lost.

LITERATURE.

- (1) MONIEZ. Note sur deux espèces nouvelles de *Tænia* inermes (*T. Vogti* et *T. Benedeni*); Bulletin scientifique du Département du Nord, 1878, II, pp. 163-164.
- (2) RAILLIET. Éléments, etc., 1886, p. 261.
- (3) NEUMANN. Traité, etc., 1st ed., 1888, p. 383.
- (4). ———— Observations sur les *Ténias* du Mouton; Comp. rend. d. l. Soc. d'Hist. Nat. d. Toulouse, 1891, 18 Mars.
- (5) MONIEZ. Notes sur les Helminthes; Rev. Biol. du Nord, 1891.
- (6) R. BLANCHARD. Notices helminthologiques, 2 sér.; Mém. d. l. Soc. Zool. d. France, 1891, p. 447, footnote.
- (7) NEUMANN. Traité, 2 ed., p. 408;—Engl. Transl., p. 419.

HISTORICAL REVIEW.

Moniez found a strobila $1\frac{1}{2}$ feet long in a sheep, and gave the following description (1) of it: Head unknown; color of strobila, white; the young segments remain very narrow for a considerable distance of the total length; the largest segments measure 2.5^{mm} broad by 5^{mm} long, and contain eggs with the pyriform body; they are very flat; the muscles are better developed than in the other species, and are not grouped. It is very rare, having been found but once.

Railliet (2) and Neumann (3) take their diagnoses from Moniez. In (4) Neumann adds nothing to the above in his text, but in the analytical table he gives *T. Vogti* as having but a single genital pore to each segment. In Moniez's paper, however, I do not find any authority for this statement.

Moniez (5) then places this species in his analytical table as *Anoplocephala Vogti*, under the line "Un seul pore genital par anneau." This, however, is too indefinite, as the genus *Anoplocephala* in Blanchard's classification has unilateral pores.

Blanchard (6) calls attention to this last point, and states that this species is more closely allied to the genus *Bertia*, since the pores are irregularly alternate. I have been unable to obtain any specimens of this species.

CONCLUSIONS.

From this review it is seen that the *T. Vogti* is not sufficiently well known to be accepted as a true species. There is considerable doubt as to the genital pores, and our experience with *Th. Giardi* has taught us that great difference of opinion may arise in such a case, and that the pores alone are no criterion in the generic determination. Furthermore, the fact that the segments are longer than broad is by itself, unassociated with other characters, of little value, for we find that several species sometimes show this character.

In Hassall's collection is found a worm from sheep, the ripe segments of which agree in breadth with Moniez's description of *T. Vogti*, but the genital pores are distinctly double. In external appearance (Plate

xvi, Figs 1-2b) the worm is totally different from any tapeworm we have ever seen. While somewhat inclined to believe that this represents a new species—in case it is not identical with *T. Vogti*—I refrain from describing it as such, since the material is so poorly preserved that the internal organs will not stain. I am unable on this account to give any description of the internal anatomy, except that the vas deferens is very much convoluted, and that the uteri are present which resemble those of *Moniezia*. The time is passed when an author is justified in describing a tapeworm as a new species unless he can give a recognizable diagnosis. C. W. S.

(16) **Tænia crucigera* Nitzsch and Giebel, 1866.

Host.—*Capreolus caprea*.

Geographical distribution.—Germany, found but once, by Nitzsch.

LITERATURE.

GIEBEL, C. Die im zoologischen Museum der Universität Halle aufgestellten Eingeweidewürmer nebst Beobachtungen über dieselben; Zeitschrift für die gesammten Naturwissenschaften, 1866, xxviii, p. 259.

Giebel describes a species of tapeworm collected by Nitzsch* from *Capreolus caprea*. His diagnosis and description are as follows:

T. capite obtuso obverse pyramidalis tetragona collo brevi; articulis anticis tenuissimis, insequentibus latequadratis, ultimis subquadratis margine laterali arcuatis posteriori vix incumbens; vulvis oppositis.

“Im März zwei Exemplare von je 3 und 1½ Fuss Länge, letztes noch ohne abgehende Proglottiden. Der Kopf its umgekehrt kegelförmig oder pyramidal, hinten am breitesten und fast wie abgeschnitten, mit vier hochrandigen mehr nach vorn als zur Seite gerichteten Saugnäpfen, die von vorn gesehen länglich viereckig, gleichsam mit eingedrücktem Kreuz bezeichnet sind. Der Halstheil hat halbe Kopfbreite und etwa die sech bis siebenfache Kopflänge. Von ihm nimmt der Leib ganz allmählig an Breite zu bis zum Ende, wo er vier Linien Breite misst. Die ersten Glieder gleichen bloss sehr feinen Runzeln, werden dann allmählig länger, anfang $\frac{1}{10}$, dann $\frac{1}{5}$ — $\frac{1}{4}$ — $\frac{1}{3}$ zuletzt $\frac{2}{3}$ ihrer Breite läng, gestreckt viereckig, am hintern Rande nur sehr wenig breiter wie am vordern. Der Seitenrand der vordern Glieder in 3 bis 4 Zoll Entfernung vom Kopfe erscheint durch zwei Hervorragungen gekerbt, deren vordere die Genitalwarze, die hintere die hervorstehende Hinterecke ist. Erste bildet ein sehr breites kurzes aufsitzendes Knöpfchen mit deutlicher Oeffnung. Weiter nach hinten wird die Geschlechtspapille schwächer, schon in der Leibesmitte ist sie ganz schwach und in dem letzten Leibesdrittel fehlt sie ganz. Der Hinterrand jedes Gliedes liegt hier nur ganz kurz und unbedeutend auf dem Vorderrande des folgenden auf, bei der nächst verwandten *T. expansa* überragt jener sehr beträchtlich. Nahe des Seitenrandes der Glieder macht sich der Seitenkanal als dunkler Streif sehr bemerklich, nur in den ersten Gliedern nicht erkennbar. Die letzten Glieder sind ganz mit grossen reifen Eiern gefüllt, welche käseförmig gestaltet also in den breiten Seiten kreisrund, vom Rande gesehen länglich sind. Die Unterschiede dieser Art von der sehr ähnlichen vorigen sind folgende: Die Saugnäpfe stehen sehr nach vorn und sind röhriger; der Halstheil ist deutlicher und länger, die hinteren Glieder in Verhältniss ihrer Breite weit länger; der Hinterrand der Glieder wenig oder gar nicht überragend; die Geschlechtspapille knopfförmig, die Eier käseförmig, nicht konisch.”

* Type specimen is lost.

From the above it is very probable that this species belongs to the genus *Moniezia*, although, without the internal anatomy, even this point is uncertain.

Dr. Brandes, in reply to a letter, has written that the type specimen has, unfortunately, been lost or destroyed. It would be too uncertain to determine a worm by the above description without the original material at hand, so that it will probably be better to ignore this specific name and diagnosis entirely.

C. W. S.

(17) *Tænia capreoli* Viborg, 1795 and (18) *Tænia capræ* Rud., 1810.

These two species should evidently be entirely ignored, for the descriptions given are not sufficient to establish them as true species, and the types can not be found. The following remarks in regard to them are quoted from Rudolphi's *Historia Naturalis* (pp. 200-201). The forms have been referred to by several authors since Rudolphi's time, but no one seems inclined to accept the species or able to give any anatomical details in regard to them.

83. *TÆNIA CAPREOLI*.—Viborg ind. Mus. Vet. Hafn., p. 238. n. 87. b. *Tænia capreoli*. *Tænia ovina* (*expansa* n. 2.) cl. viro n. 87. a. dicitur, unde capreoli vermem huic affinem esse, eo magis colligimus, quo major inter expansam (ovis), denticulatum (bovis) et insequentem (capræ) affinitas observetur.

84. *TÆNIA CAPRÆ*.—*Hab.*—In *Capræ Hirci* intestino ileo specimina plurima, mortua, Augusto mense reperi.

Fragmenta tri- vel quinquepollicaria; quorum alia minora articulis linea angustioribus, brevissimis, angulis laterilibus acutiusculis, alia majora articulis duas tresve lineas latis, vix lineam longis. Isti crassiusculi marginibus lateralibus crenulatis, foramine utrinque medio sive opposito indistincto, angulis rotundatis, margine postico plicatulo, substantia molli, lineis transversis undulatis.

Obs. 1.—*Tænia* hæc inter expansam n. 2. et denticulatam n. 3. quas conferas, media videtur, capite tamen non viso, de eadem judicare nequeo.

Obs. 2.—Ne cum *Tænia capræ* Abilgaardii, caprina Gmelini et Zederi confundas, hæc enim *Tænia* non est, et sub *Polystomatis denticulati* nomine supra descripta sistitur.

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(See also addenda, p. 101.)

PART V.

LIFE HISTORY.

Mégnin published an article in which he set forth the theory that certain cestodes could develop without a change of host. Moniez and others combatted this idea, while Perroncito suggested that some insect might possibly play the role of intermediate host for forms like *Moniezia expansa*. McMurrich was inclined to look upon *Melophagus ovinus* as the intermediate host of *Moniezia expansa*. Leuckart has suggested that some snail might act as the intermediate host. Curtice then supported the direct infection theory again.

Hutchinson, in rather an undecided amateurish article, suggests that it is possible that caterpillars, slugs, earthworms, lice, etc., may be intermediate hosts for *T. expansa*, which he "believes" is the tapeworm found in sheep and ruminants.

For over a year past we have been conducting experiments in this line, but up to date only negative results can be reported. Experiments to infect sheep directly by feeding eggs to them have been totally negative. Experiments to infect *Melophagus ovinus*, numerous coprophagous insects, and earthworms, have also been negative. It is the intention to continue these experiments, especially those with earthworms, this coming spring upon a much larger scale, and we hope later to report some positive results. From experiments thus far, however, we feel confident that cattle, etc., can not become infested with tapeworms by swallowing the eggs, as Curtice still contends, and it is believed that some insect, worm, or snail will be found to contain the larval stage.

C. W. S.

PART VI.

CONCLUSIONS.

In the foregoing studies the following conclusions have been reached:

(1) Descriptions of cestodes based upon external form alone, unassociated with internal anatomy, are of little value. (See also p. 84, 99.)

(2) In the case of those forms of which the original type specimens can be obtained, we may be able to recognize the species, but in most of the cases of which the types have been lost, the determination of the species is extremely uncertain. We shall hence be obliged to ignore a great number of forms which have been described as species.

(3) The present genus *Tania*, as generally accepted by authors, contains forms which must be restudied and arranged in several sub-families and a number of genera.

(4) This revision must be based upon internal anatomy.

(5) In the adult cestodes of cattle and sheep three genera *Moniezia* R. Bl., *Thysanosoma* Dies., and *Stilesia* Rail., are recognized.

(6) For a summary of the genus *Moniezia*, see p. 51; for *Thysanosoma*, p. 70; for *Stilesia*, p. 82.

(7) The following table will aid in determining the various species of these genera:

1	{	Uterus double; genital pores double; eggs with well developed pyriform apparatus.....	MONIEZIA R. Bl. 2
		Uterus single, transverse, with ascon-spore like eggs-sacs; genital pores double or irregularly alternate; horns of the pyriform apparatus not developed.....	THYSANOSOMA Dies. 10
		Uterus single or double and without ascon-spore like egg-sacs; genital pores irregularly alternate; eggs with a single shell; strobila narrow; testicles absent from median portion of median field.....	STILESIA Rail. 11
		Species inquirendæ	9, 12
2	{	MONIEZIA. For generic diagnosis, see p. 54.	
		Interproglottidal glands absent	3
3	{	Interproglottidal glands present.....	4
		Genital pore in anterior half of lateral margin.....	<i>M. alba</i> , p. 51
4	{	Genital pore in posterior half of lateral margin.....	<i>M. denticulata</i> , p. 46
		Interproglottidal glands linear, not grouped around blind sacs	5
		Interproglottidal glands grouped around blind sacs.....	7

- 5 { Interproglottidal glands very prominent and quite long (broad in reference to the segment); head not very distinctly lobed; opening of suckers slightly elongated; segments attain 20-26^{mm} in breadth..... *M. planissima*, p. 22
- 6 { Interproglottidal glands short and not prominent..... 6
- 6 { Head very distinctly lobed and sharply separated from neck; opening of sucker round; neck nearly as broad as head; segments attain 10-12^{mm} in breadth..... *M. Benedeni*, p. 25
- 6 { Lobing of head less distinct; head not so sharply separated from neck; neck filiform; segments attain 8^{mm} in breadth; thinner than foregoing species..... *M. Neumanni*, p. 26
- 7 { Testicles generally in form of two triangles; space frequently left between the uteri in the median line; head pyriform, almost square when viewed *en face*; segments attain 6^{mm} in breadth; end segments occasionally as long as broad..... *M. trigonophora*, p. 42
- 7 { Testicles generally in form of a quadrangle; no space between the fully developed uteri; end segments never as long as broad 8
- 8 { Head oblong when viewed *en face*; not lobed; suckers not distinctly raised; entire strobila thin; segments attain 9 mm. in breadth; end segments narrower *M. oblongiceps*, p. 36
- 8 { Head more or less distinctly lobed; nearly square when viewed *en face*; suckers raised; openings decidedly elongated; strobila often quite thick; posterior portion frequently of an orange color; segments attain 16 mm., perhaps more, in breadth; end segments show a tendency to break off 1-3 at a time *M. expansa*, p. 34
- 9 { Neck absent; head large, decidedly lobed; openings of suckers round; segments attain 8 mm. in breadth—sp. inq. *M. nullicollis*, p. 83.
- 10 { THYSANOSOMA.—For generic diagnosis, see p. 70
- 10 { Head very large (1.5 mm); square; lobed; testicles in median field; posterior flap of segments fimbriate; genital pores double *Th. actinioides*, p. 58
- 10 { Head small; testicles in lateral fields; posterior flap not fimbriate; genital pores irregularly alternate (rarely double)..... *Th. Giardi*, p. 69
- 11 { STILESIA.—See p. 82.
- 11 { Median portion of median field occupied by a transverse uterus; "head 2 mm. in diameter" *S. centripunctata*, p. 81.
- 11 { Median portion of median field transparent; two lateral uteri in each segment; "head less than 1 mm. in diameter"..... *S. globipunctata*, p. 79.
- 12 { Segments 2 mm. broad by 5 mm. long, sp. inq..... *T. Vogli*, p. 83.
- 12 { End segments 8 mm. broad, sp. inq *T. crucigera*, p. 85.

(8) For *Tania marmotæ* we shall be compelled to recognize a new genus (p. 71).

(9) Riehm's species *Dipylidium Leuckarti*, *D. pectinatum* and *D. latissimum* can not remain in the genus *Dipylidium*, established by Leuckart for *Tania cucumerina*. It may be found upon further study that they can be placed in the genus with *T. marmotæ*.

C. W. S.

PART VII.

COMPENDIUM OF SPECIES ARRANGED ACCORDING TO THEIR HOSTS.

I have personally examined those forms marked with an asterisk (*) under the various hosts, and can hence guarantee that these species occur in the animals cited. The other cases mentioned are compiled. Forms given as *M. expansa*, but not starred, should be reëxamined to establish their specific identity.

The nomenclature of the hosts here adopted is mainly that of Flower and Lydecker's Mammals, Living and Extinct, 1891. In the case of the *Cervidæ*, Sir Victor Brooke's Monograph (Proc. Zool. Soc., London, 1878 pp. 883-928) of this family has been followed:

Antilope dorcas Pallas. See GAZELLA DORCAS.

Antilocapra rupicapra Exl. See RUPICAPRA TRAGUS.

BOS INDICUS. Zebu.

Moniezia expansa (R.) R. Bl., reported as *Tania expansa*.

BOS TAURUS L. Domestic cattle.

* *Moniezia alba* (Per.) R. Bl.

* *Moniezia Benedeni* (M.) R. Bl.

* *Moniezia denticulata* (R.) R. Bl.

* *Moniezia expansa* (R.) R. Bl.

* *Moniezia planissima* S. & H.

Thysanosoma Giardi (Riv). S. ₁ (See p. 59.) Found by Perroncito; determined by Rivolta.

Stilesia centripunctata. (See p. 79.)

Stilesia globipunctata. (See p. 73.)

CAPRA HIRCUS L. Goat.

Moniezia expansa (R.) R. Bl., reported as *Tania expansa*.

Tania capra R. sp. dub.

Capra hispanica Græl. See CAPRA PYRENAICA.

CAPRA PYRENAICA Schinz. (*Capra hispanica*.) Spanish Ibex.

Moniezia expansa (R.) R. Bl., reported as *Tania expansa*.

CAPREOLUS CAPREA. (*Cervus capreolus*.) Roe or Roe deer.

Moniezia expansa (R.) R. Bl., reported as *Tania expansa*.

Tania crucigera Nitzsch, sp. dub.

CARIACUS (BLASTOCERUS) CAMPESTRIS. (*Cervus campestris*.) Pampas Deer.

Moniezia expansa, reported as *Tania expansa*.

CARIACUS (BLASTOCERUS) PALUDOSUS. (*Cervus paludosus*.)

Thysanosoma actinioides Dies.

CARIACUS (COASSUS) NAMBI. (*Cervus nambi*.)

Moniezia expansa (R.) R. Bl., reported as *Tania expansa*.

Thysanosoma actinioides Dies.

- CARIACUS (COASSUS) RUFUS. (*Cervus rufus*.) Brocket.
Moniezia expansa (R.) R. Bl., reported as *Tenia expansa*. (See Diesing.)
Thysanosoma actinioides Dies.
- CARIACUS (COASSUS) SIMPLICICORNIS. (*Cervus simplicicornis*.)
Thysanosoma actinioides Dies.; found by Natterer.
- CARIACUS (COASSUS) SP. ?
**Moniezia oblongiceps* S. & H.
- Cervus campestris*. See CARIACUS (BLASTOCERUS) CAMPESTRIS.
Cervus capreolus. See CAPREOLUS CAPREA.
Cervus dichotomus. See CARIACUS PALUDOSUS.
Cervus namibi. See CARIACUS NAMBI.
Cervus paludosus. See CARIACUS PALUDOSUS.
Cervus rufus Cuv. See CARIACUS (COASSUS) RUFUS.
Cervus simplicicornis. See CARIACUS SIMPLICICORNIS.
- GAZELLA DORCAS. (*Antilope dorcas*.) Gazelle.
**Moniezia expansa* (R.) R. Bl., one of Rudolphi's original specimens.
- OVIOS MOSCHATUS (Zimm). Musk ox.
Moniezia expansa (R.) R. Bl.
- OVIS ARIES L. Domestic sheep.
**Moniezia alba* (P.) R. Bl.
**Moniezia Benedeni* (M.) R. Bl.
**Moniezia expansa* (R.) R. Bl.
**Moniezia Neumanni* Moniez.
**Moniezia nullicollis*, Moniez, sp. dub.
**Moniezia planissima* S. & H.
**Moniezia trigonophora* S. & H.
**Thysanosoma actinioides* Dies.
**Thysanosoma Giardi* (Riv.) S.
**Stilesia centripunctata* (Riv.) Rail.
**Stilesia globipunctata* (Riv.) Rail.
- RUPICAPRA TRAGUS Gray. (*Antilope rupicapra*.) Chamois or Gemse.
Moniezia expansa (R.) R. Bl., reported as *Tenia expansa*.

PART VIII.

BIBLIOGRAPHY OF ADULT CESTODES OF CATTLE AND SHEEP.

We have not been able to find the articles the numbers of which are inclosed in brackets, thus []:

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(*T. expansa*, p. 150; *T. denticulata*, p. 151.)
2. BAILLET. Histoire Naturelle des Helminthes des principaux mammifères domestiques. Paris, 1866. (Extr. d. Nouv. Dict. d. Méd., d. Chir. et d'Hyg. vét.)
(*T. expansa*, p. 161; *T. denticulata*, p. 161; *T. capræ*, p. 162.)
- [3] BATSCH, A. J. G. C. Naturgeschichte der Bandwurm-gattung überhaupt und ihrer Arten insbesondere, nach den neuern Beobachtungen in einem systematischen Auszuge. Halle, 1786.
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Several other references were found but we have been unable to trace the articles.

S. & H.

ADDENDA.

As the manuscript of the preceding pages left the author's hands some months ago, it may be well to add a postscript covering several interesting observations made since that time. During the past six months it has been possible to examine a large number of specimens of adult cestodes of cattle and sheep, and thus to put the analytical table given on pp. 88, 89 to a very severe test. The parasites examined came from the several sources enumerated below:

(a) Thirty strobilæ collected by Dr. Melvin and assistants at the abattoirs of the Union Stock Yards of Chicago. These strobilæ were preserved in weak alcohol and did not come into my hands until they were quite macerated. Although disappointed at first because the material was not in better condition, its examination has led to some very important and rather unlooked-for results.

(b) A few segments of Rudolphi's original *Tania capra*, kindly forwarded by Geheimrath Karl Möbins.

(c) About 100 strobilæ of *Moniezia* from cattle and sheep collected by Dr. Hassall at the Washington (D. C.) abattoir, and fixed according to the method described on pp. 13, 14.

(d) Several jars of tapeworms from sheep belonging to the Leidy collection, University of Pennsylvania. The specimens are all members of the genus *Moniezia*, but are very much macerated.

(e) Several strobilæ collected by Dr. Theobald Smith.

(f) About 100 strobilæ collected by myself in August, from cattle at the abattoirs of Chicago, and preserved according to the method described on p. 13.

The specimens collected by Hassall and myself were very readily determined as belonging to the species *M. planissima*, *M. expansa*, and *M. trigonophora*. Several strobilæ bear a very close resemblance to *M. Neumanni*, but I am not willing at present to state definitely that they belong to that species. A study of the forms not "fixed" before being placed in alcohol emphasized the importance of not relying upon external form in making the specific determinations—a point to which attention has already been drawn in the text—for it is the easiest thing in the world to determine an *M. expansa* as *M. planissima*, or *vice versa*. If microscopic preparations are made, however, there is not the slightest difficulty in distinguishing the *Planissima* group from the *Expansa* group. In many cases, however, it is difficult to distinguish *M. expansa* from *M. trigonophora* by examining only one or two segments, but the species are easily separated by a more careful study.

The specimens of Leidy's collection, although too macerated to be determined specifically, could easily be divided into the *Planissima* group and the *Expansa* group.

The results of the study confirm the position taken in the preceding text, that the form of the interproglottidal glands furnishes a basis for a natural division into the *Planissima* group and the *Expansa* group. I am led, however, to doubt the advisability of placing very much stress upon the size of the glands in the *Planissima* group as a criterion in determining the species; in several cases strobilæ were found which agreed with *M. planissima* in all respects except that the head was much larger and the linear glands extended the entire (or almost the entire) width of the segment. Preferring to be conservative, I have deemed it best for the present to look upon these specimens as the *M. planissima* rather than to create a new species for them, for in studying parasites, as well as other animals, *we must expect to find individual variation*. This variation can, for the present, be held to account for the enormous size of the linear glands. The enormous size of the heads in several specimens *might possibly* be accounted for by *individual variation* and *method of preservation*, for I have studied the live heads a number of times, and find that, in their contraction, they can change in size to a considerable degree.

An interesting fact was developed in comparing unfixed and fixed material with Perroncito's types of *M. alba*. Specimens of *M. planissima* when fixed with sublimate bear absolutely no resemblance to Perroncito's *M. alba* (the type specimens of *T. alba* were evidently preserved in alcohol without first being treated with sublimate); specimens of *M. planissima* which have not been fixed in sublimate, but have remained in weak (50 per cent) alcohol for some time, differ from specimens which have been fixed in sublimate to a marked degree. In fact, when I first examined the specimens macroscopically I was entirely at a loss to know to which species they might possibly belong. A microscopic examination of a number of slides, however, left no doubt that they were typical specimens of *M. planissima*, and that any difference in the form of the segments or the general appearance of the strobilæ should be accounted for by considering the different methods used in preserving the specimens. Next came an interesting, and to my mind, an important observation, *i. e.*, that a few of the more poorly preserved of the alcohol specimens bore a remarkable macroscopic resemblance to Perroncito's type of *T. alba*. In fact, in the case of one specimen the resemblance was so striking that when I compared it side by side with one of Perroncito's specimens I was unable to tell which was the Italian and which the American form without comparing the labels. Having called attention to this remarkable macroscopic resemblance, it is in place to compare the microscopic slides. In no case have I found a single slide, in the many preparations made from three of Perroncito's types, in which there was the slightest trace of interproglottidal glands; on the other hand, I have never failed to find these linear glands in the segments of *M. planissima* which were treated with sublimate; in the vast majority of cases those nonfixed specimens of American tape-

worms which did not belong to the *Expansa* group have possessed linear interproglottidal glands. Most of these are undoubtedly our *M. planissima*; on the other specimens I prefer to reserve judgment for the present. The same character was present in French specimens sent to me by Railliet and Neumann. Now, curiously enough, seven nonfixed fragments of American forms fail to show any signs of interproglottidal glands. These specimens are poorly preserved, but not badly macerated; under the microscope they can not be distinguished from *M. alba*. I should not think of uniting them with *M. planissima*, on account of the absence of the linear interproglottidal glands; if such glands were present they would probably have been brought out by staining, for we have frequently found these glands in fragments which were more macerated than those now under discussion. If pressed to a determination of these fragments, I should accordingly label them *M. alba*, although rather unwillingly, because they are only fragments and are the only specimens of *M. alba* (?) ever collected in America.

I might add, further, that two of Perroncito's types agree perfectly with each other when examined macroscopically, while the third, as well as Neumann's specimens, would probably not be united with *M. alba* by any worker except after a careful microscopic study.

To recapitulate, in a few words, we may conclude that—

(1) Specimens of a species fixed in sublimate may differ so in macroscopic appearance from specimens of the same species simply preserved in alcohol that scarcely any helminthologist would hesitate to recognize them as belonging to different species.

By using different methods of preservation and different degrees of maceration it has been found possible to bring about such a variation in external form of different specimens of *M. planissima* and *M. expansa*, or of different portions of the strobila of a single specimen that almost any species (if established on external form alone) can be made to order.

(2) It is entirely unsafe to determine a given specimen of *Moniezia* as *M. planissima*, *M. expansa*, or in fact as almost any other species without first examining several stained segments. Segments with well-developed testicles and ovaries are the best for this purpose.

(3) As specimens macerate, the linear interproglottidal glands of *M. planissima* stain less distinctly.

(4) In Perroncito's type of *M. alba* there is no trace of any interproglottidal glands; these specimens were evidently not fixed in sublimate before being placed in alcohol, but they are not badly macerated.

(5) One specimen of an undoubted *M. planissima* resembles one specimen of Perroncito's type so very closely (macroscopically) that no zoölogist would hesitate to pronounce the two specifically identical, were it not that linear glands are present in the former and absent in the latter.

(6) The specimen of *M. alba* referred to (5) bears no macroscopic resemblance to Perroncito's other two types, nor to his figures of this species, but on account of the absence of the glands it must be united with *M. alba*.

Upon reading the above, some of my European colleagues will undoubtedly conclude that *M. planissima* and *M. alba* are specifically identical, that the absence of the linear gland is to be accounted for by maceration, and that we have been too hasty in creating *M. planissima* as a new species. Such a conclusion would, however, be entirely unjustified unless the person based his opinion on a careful study of the types and a large series of typical specimens. If anyone is able to find linear interproglottidal glands in Perroncito's types and to prove that Perroncito's types contain but one species, then he would be perfectly justified in uniting *M. planissima* and *M. alba* as one species, and no one would be more willing to accept his results than Hassall and myself. I have not been able to find these glands in *M. alba*, but have found them in every specimen of tapeworm of the genus *Moniezia* except those of the *Expansa* group, the few segments of *M. denticulata* now at my disposal, in Perroncito's and Neumann's specimens of *M. alba*, and the few fragments mentioned above as *M. alba* (?).

This Bureau has already sent to a number of zoölogists typical specimens (stained slides and alcohol specimens) of the forms described in this paper, and it can safely be left to European specialists to decide whether we were justified in creating the species *M. planissima*, and it is needless to add that the Bureau types and preparations are always at the disposal of specialists in helminthology. I feel that we have solved the question of the classification of this genus so far as it applies to the American forms and to the limited amount of European specimens at our disposal. If we have made any errors in judging the European forms they can best be corrected by our European colleagues. Looking to the possibility of an European revision of this genus in the future I should like to call particular attention to the following points:

(1) Are the scarcely visible linear glands in *M. Benedeni*, mentioned in this paper, in reality interproglottidal glands or have I here mistaken some of the more intensely stained subcuticular cells for glandular cells? This point can be determined only by an examination of properly preserved, freshly collected material. If I have here made an error of interpretation, the species should be placed in the "*Denticulata* group."

(2) Are interproglottidal glands present in freshly collected and properly preserved material of *M. denticulata*?

(3) Can the species *Stilesia centripunctata* remain in the same genus with *S. globipunctata*? This certainly can not be so unless we find more points of resemblance between the two forms than we know at present.

(4) Any classification of any genus of tapeworms, based upon external form alone, can not claim the attention of specialists. Anatomy must form the basis of our future revisions.

(5) Individual variation must be taken into consideration in the study of parasites just as well as in the study of other animals. Slight, or, in many cases, even considerable, difference in the size of the head, form of the segments, etc., can often be explained as due to different methods of preserving.

Moniezia capræ sp. inq.

The segments of Rudolphi's *T. capræ*, now in my possession, warrant but one statement, *i. e.*, that the species is evidently a true *Moniezia*.

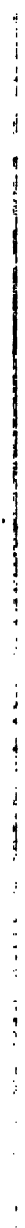
The proglottids are so crowded with ova that one would scarcely expect to distinguish the interproglottidal glands, even if they are present. Experience in comparing the external form of specimens has taught me so many lessons that I would not even dare to speculate as to the possible affinities of this specimen with the other species of *Moniezia*.

Thysanosoma actiniodes.

This species has been found in South Africa (personal conversation with Dr. S. Wiltshire).

C. W. S.

OCTOBER 28, 1893.



INDEX TO SPECIFIC NAMES.

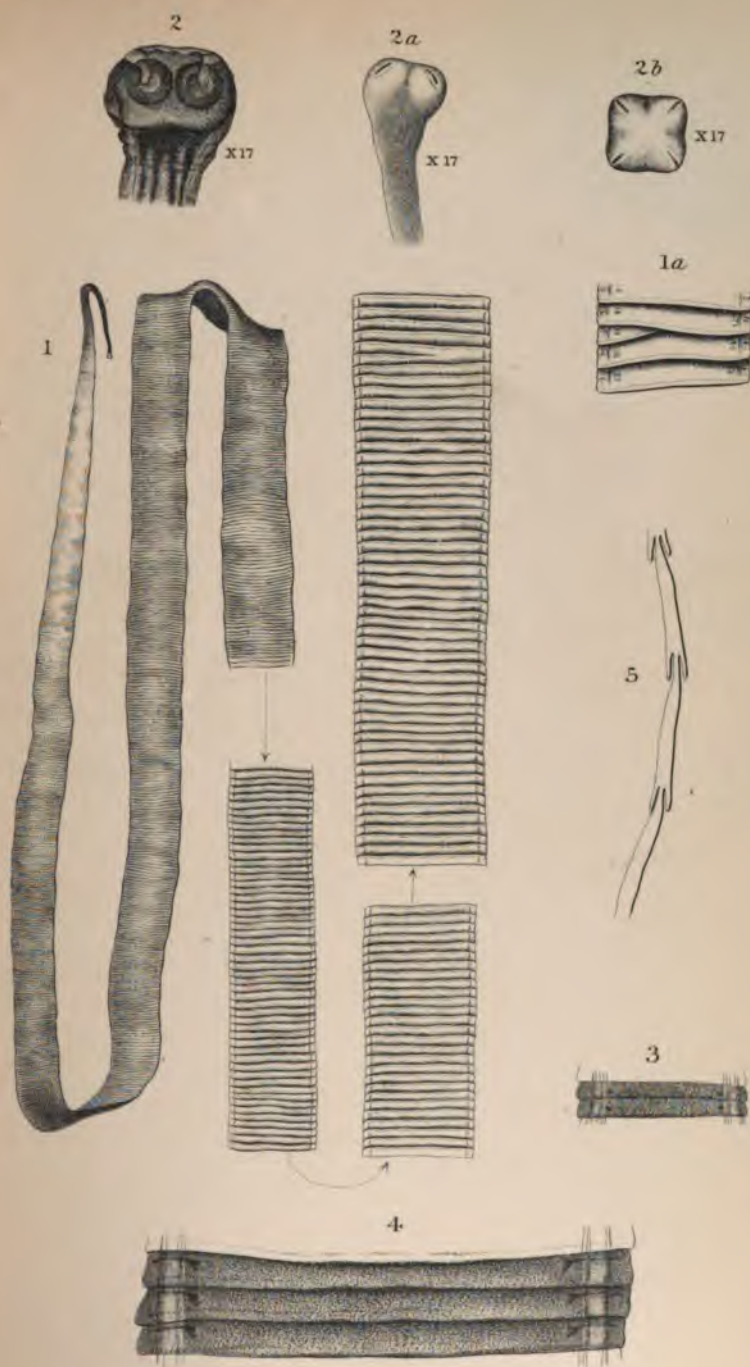
The names in italics are synonyms. In the case of such forms as *T. marmota*, *T. pertinata*, etc., whose generic position is somewhat uncertain, I have retained them provisionally in the collective genus *Tænia*, pending the establishment of new genera. Private advices from Prof. Railliet inform me that he intends to establish several new genera in the second edition of his *Traité de Zoologie médicale et agricole* (now in press). According to Prof. Railliet's letters he has adopted the MS generic name *Andrya* for *T. marmota* and *Clenotænia* and *Rhopalocephala* for Riehm's species. As Railliet's second edition has not yet reached this country, at the time of the final proof-reading and indexing of this bulletin, I am not in a position to state positively whether Railliet has retained in his work the manuscript names given above, and the reader must, therefore, be referred to Railliet's publication for the generic names to be employed in connection with the species in question. C. W. S.

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*Original article not at my disposal.

PLATE I.—*Moniezia planissima*.

- Fig. 1. Adult strobila, natural size, slightly contracted.
Fig. 1a. Ripe segments, uncontracted.
Fig. 2. Head, ventral view, balsam preparation. $\times 17$.
Fig. 2a. Head, alcohol specimen. $\times 17$.
Fig. 2b. Head, *en face*, alcohol specimen. $\times 17$.
Fig. 3. Segments, 10^{mm} from the anterior extremity, showing the first appearance of the genital anlagen.
Fig. 4. Segments, 70^{mm} from the anterior extremity, showing the pistol-shape anlagen of the genital canals.
Fig. 5. Sagittal section, 20^{cm} from the anterior extremity, showing the overlapping posterior flap of each segment.



HAINES, DEL.

A. HOEN & CO.

MONIEZIA PLANISSIMA

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PLATE II.—*Moniezia planissima* and *M. Benedeni*.

Figs. 1-6 *M. planissima*.

Fig. 1. Diagram of the female organs, dorsal view: *r. s.*, receptaculum seminis; *ov.*, ovary; *s. g.*, shell-gland; *r. g.*, vitellogene gland; *r. dt.*, vitello-duct; *o. d.*, *o. d'*, *o. d''*, oviduct.

Fig. 2. Frontal section of the interproglottidal gland.

Fig. 3. Diagrammatic figure of a transverse section; *v.*, vagina; *c.*, cirrus; *n.*, nerve; *v. c.*, ventral canal; *d. c.*, dorsal canal.

Fig. 4. Dorsal view of segment, 200^{mm} from the anterior extremity; *i. g.*, interproglottidal gland; *t.*, testicles; *d. c.*, dorsal canal; *v. c.*, ventral canal; *n.*, nerve.

Fig. 5. Ripe segments filled by the uteri.

Fig. 6. Ovum.

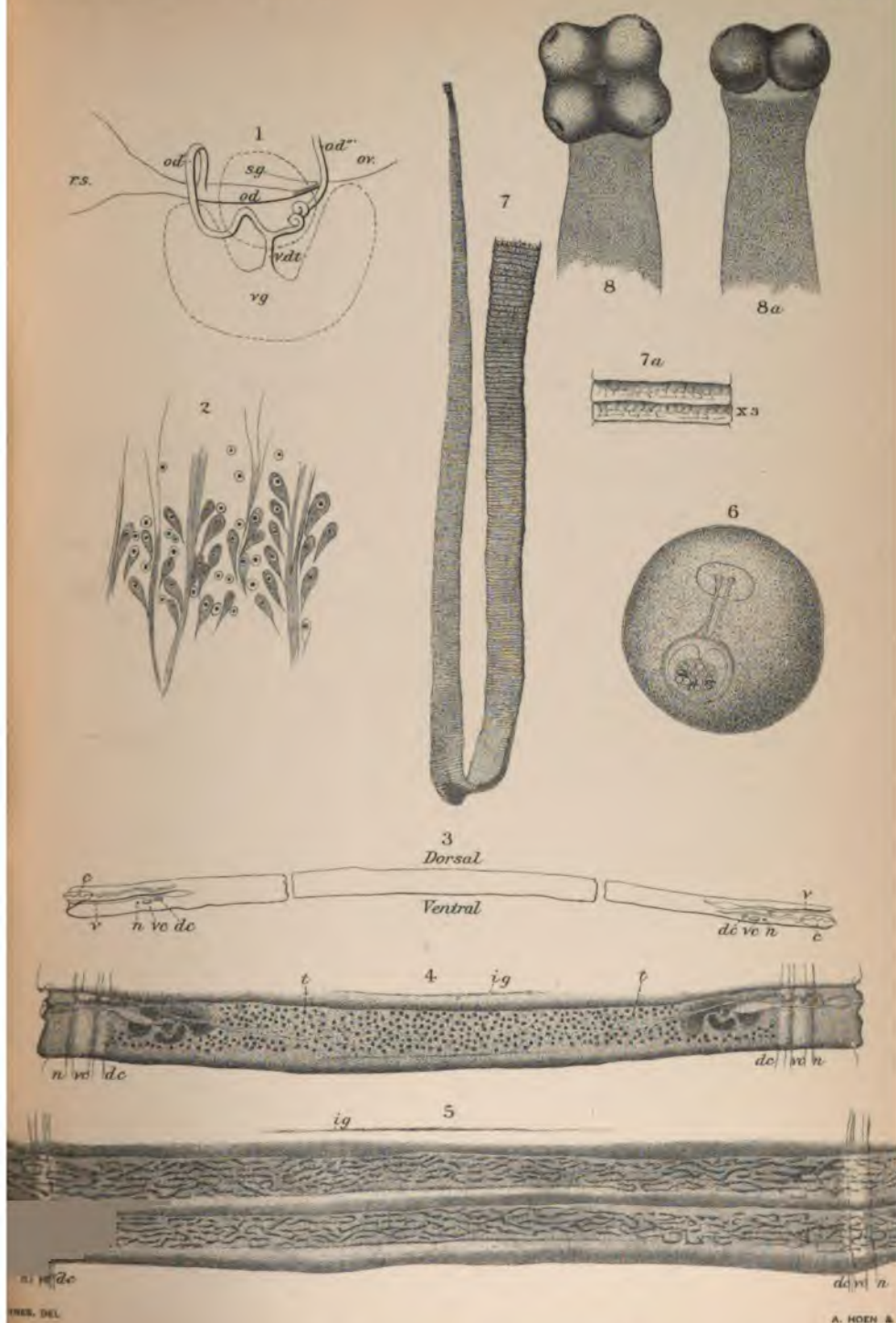
Figs. 7, 8. *M. Benedeni*, drawn from one of Moniez's original specimens.

Fig. 7. Head and strobila, natural size.

Fig. 7a. Two segments, drawn to show the peculiar architecture in contraction.

Fig. 8. Scolex, *en face*. × 17.

Fig. 8a. Scolex, ventral view. × 17.



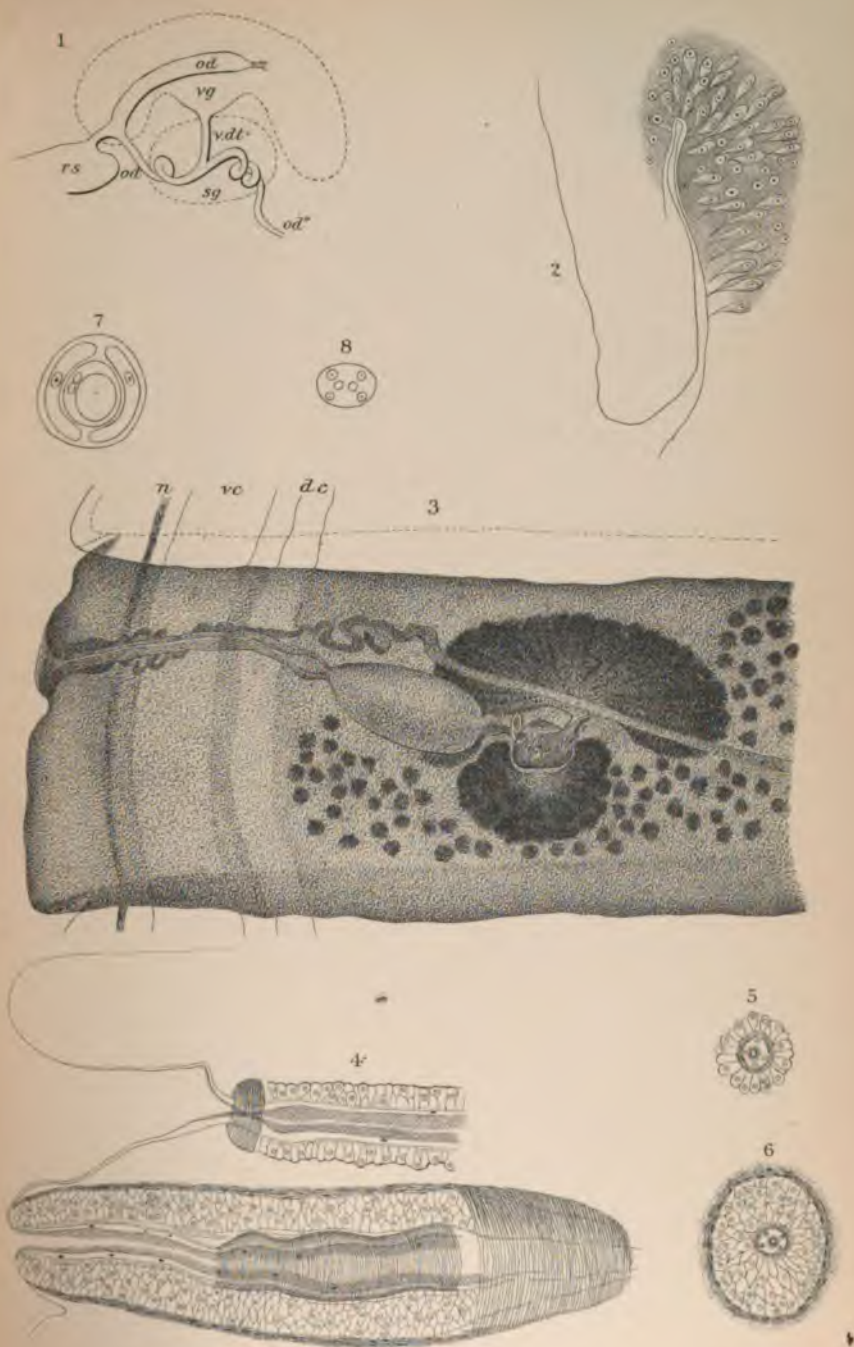
MONIEZIA PLANISSIMA

MONIEZIA BENEDENI



PLATE III.—*Moniezia planissima*.

- Fig. 1. Transverse projection of the female canals, diagrammatic.
- Fig. 2. Sagittal section of the interproglottidal gland.
- Fig. 3. Portion of segment, showing the genital organs.
- Fig. 4. Longitudinal section of cirrus and vagina, slightly diagonal.
- Fig. 5. Transverse section of vagina.
- Fig. 6. Transverse section of cirrus.
- Fig. 7. A young egg, diagrammatic.
- Fig. 8. Disk of the pyriform body.



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MONIEZIA PLANISSIMA

PLATE IV.—*Moniezia Neumanni* (drawn from Moniez's original material).

Fig. 1. Fragments (contracted) natural size.

Fig. 2. Head, ventral view. $\times 17$.

Fig. 2a. Head, *en face*. $\times 17$.

Fig. 3. Segments with testicles and anlagen of the genital canals. (Ventral view).

Fig. 4. Same, greatly enlarged.

Fig. 5. Segment with fully developed uterus.

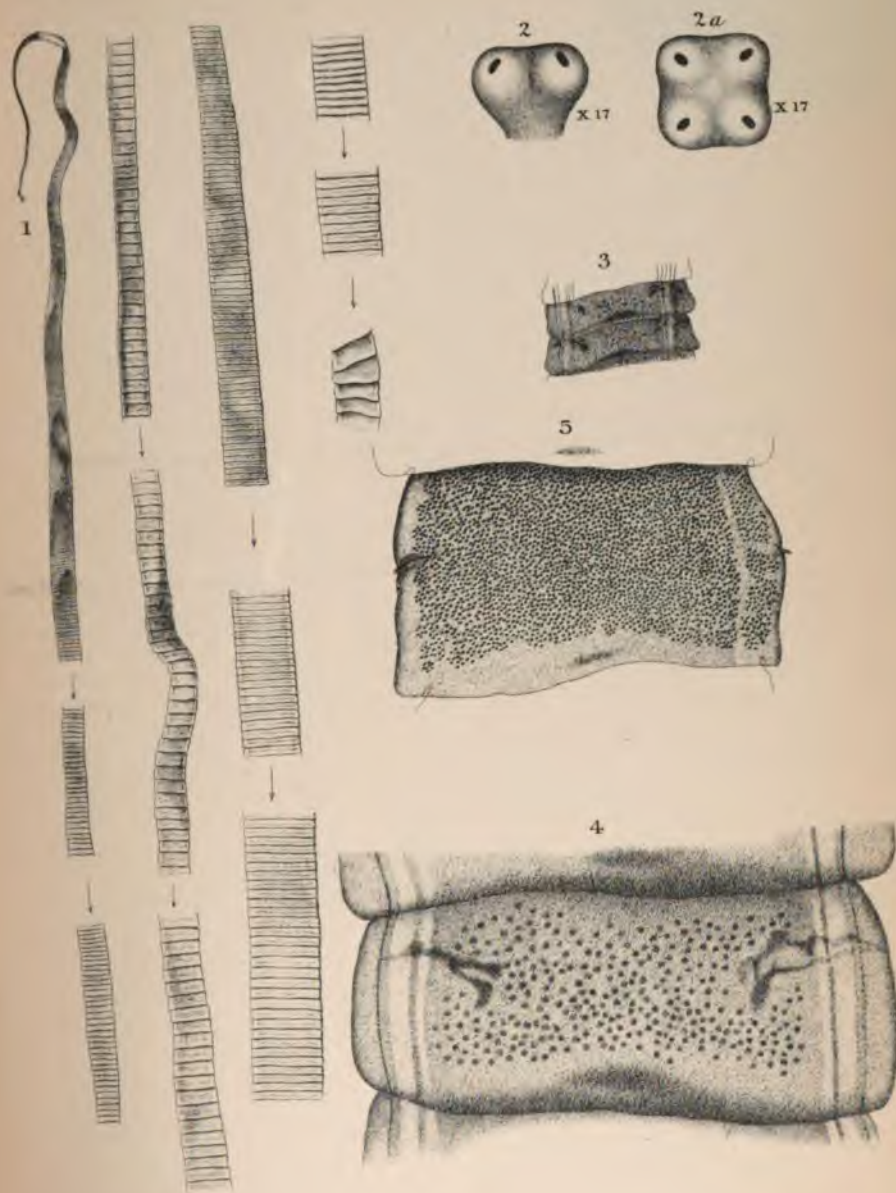


PLATE V.—*Moniezia expansa* and *M. denticulata*.

Figs. 1-3. *M. expansa*, drawn from Rudolphi's original material (1810). Orig.

Fig. 1. Scolex, ventral view. $\times 17$.

Fig. 1a. The same, *en face*. $\times 17$.

Fig. 1b. The same, viewed diagonally. $\times 17$.

Fig. 2. Segments in which the uteri were not developed.

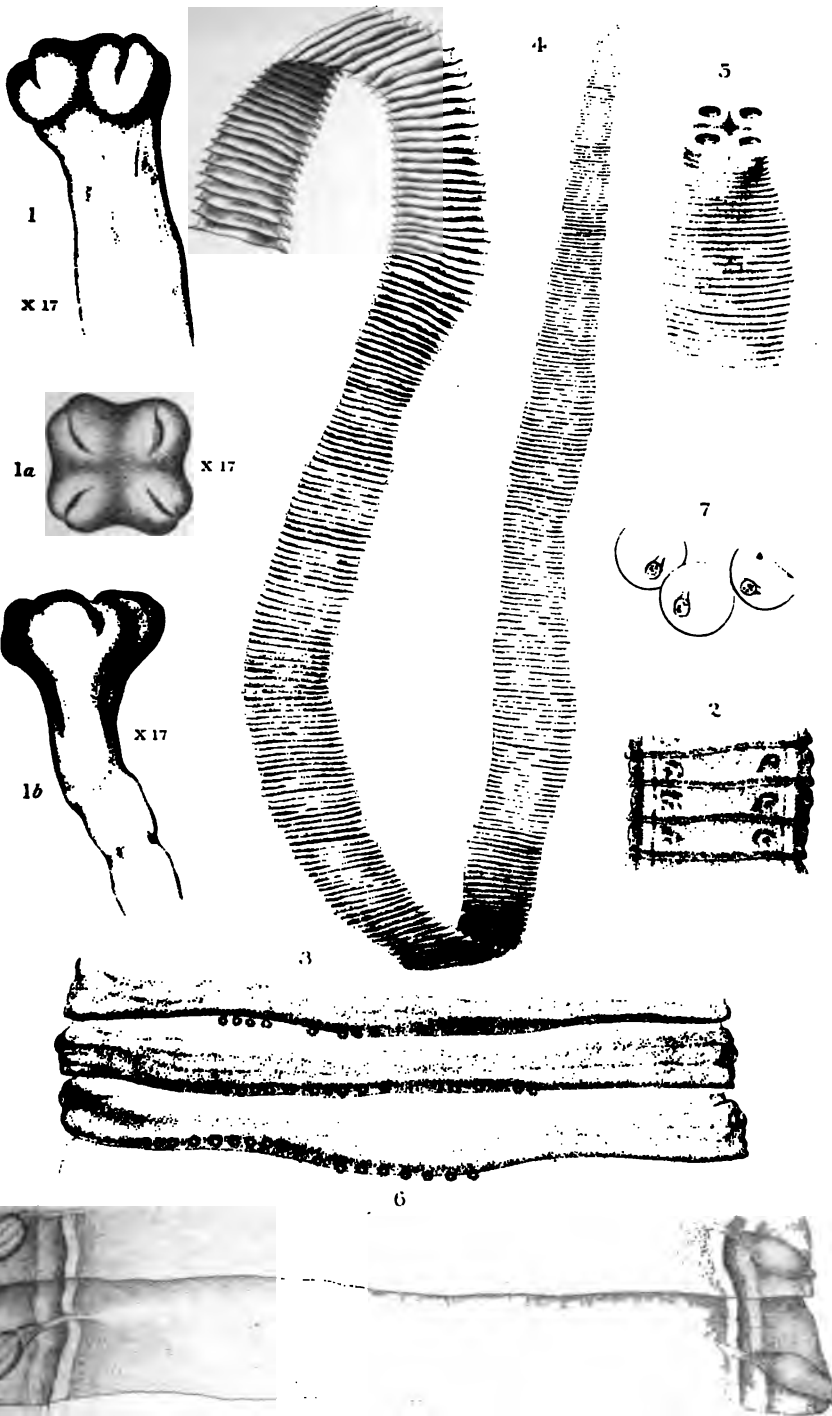
Fig. 3. Segments in which eggs were developed.

Figs. 4-6. *M. denticulata*: 4-5 drawn after Goeze's figures of Rudolphi's original material; 6 drawn from Rudolphi's original material (orig).

Fig. 4. Strobila with head, natural size.

Fig. 5. Head.

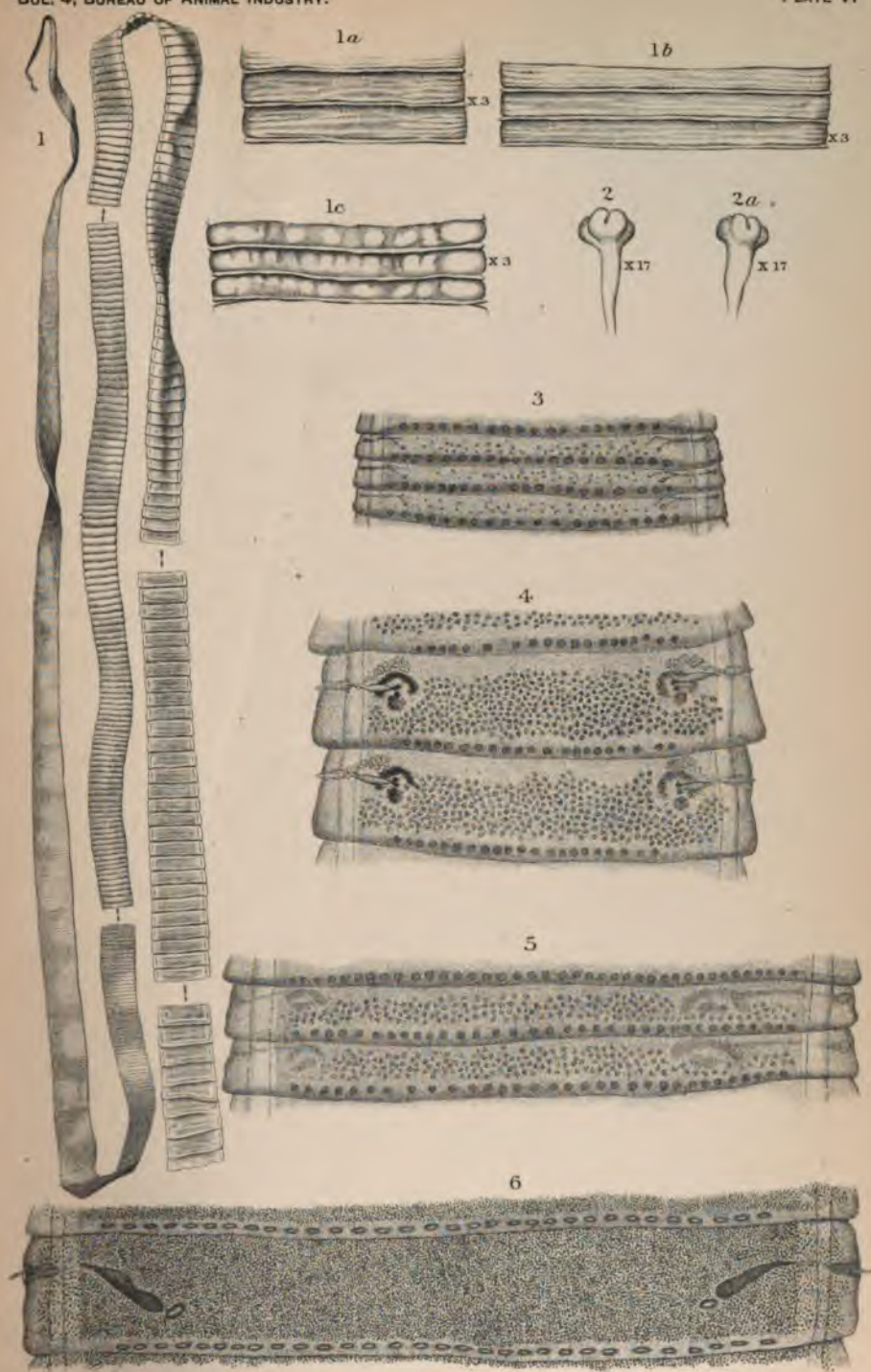
Fig. 6. Mature segments.



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MONIEZIA EXPANSA MONIEZIA DENTICULATA
RUDOLPHI'S ORIGINAL TYPES.



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MONIEZIA EXPANSA

PLATE VII.—*Moniezia oblongiceps*—*Thysanosoma Giardi*—*Taenia marmotæ*.

Figs. 1-4. *M. oblongiceps*.

Fig. 1. Strobila, natural size.

Fig. 2. Head, alcohol specimen, ventral view.

Fig. 2a. The same, *en face*.

Fig. 2b. Head, balsam preparation.

Fig. 3. Segments showing genital canals, testicles, interproglottidal glands, etc.

Fig. 4. Egg.

Fig. 5. Section of *Th. Giardi*; *g. p.*, genital pore; *r. s.*, vesicula seminalis; *r. d.*, convolutions of vas deferens with prostata; *r. d.*, vas deferens; *r.*, vagina; *r. s.*, receptaculum seminis; *o. d.*, descending oviduct; *o. d'*, ascending oviduct; *u. t.*, uterus; *o. r.*, ovarium; *v. g.*, vetellogene gland; *v. c.*, ventral canal; *d. c.*, dorsal canal; *t. c.*, transverse canal; *t.*, testes.

Fig. 6-7. *Taenia marmotæ*.

Fig. 6. Segment showing the anatomy with the exception of the uterus, dorsal view.

Fig. 7. Segments with developed uterus.

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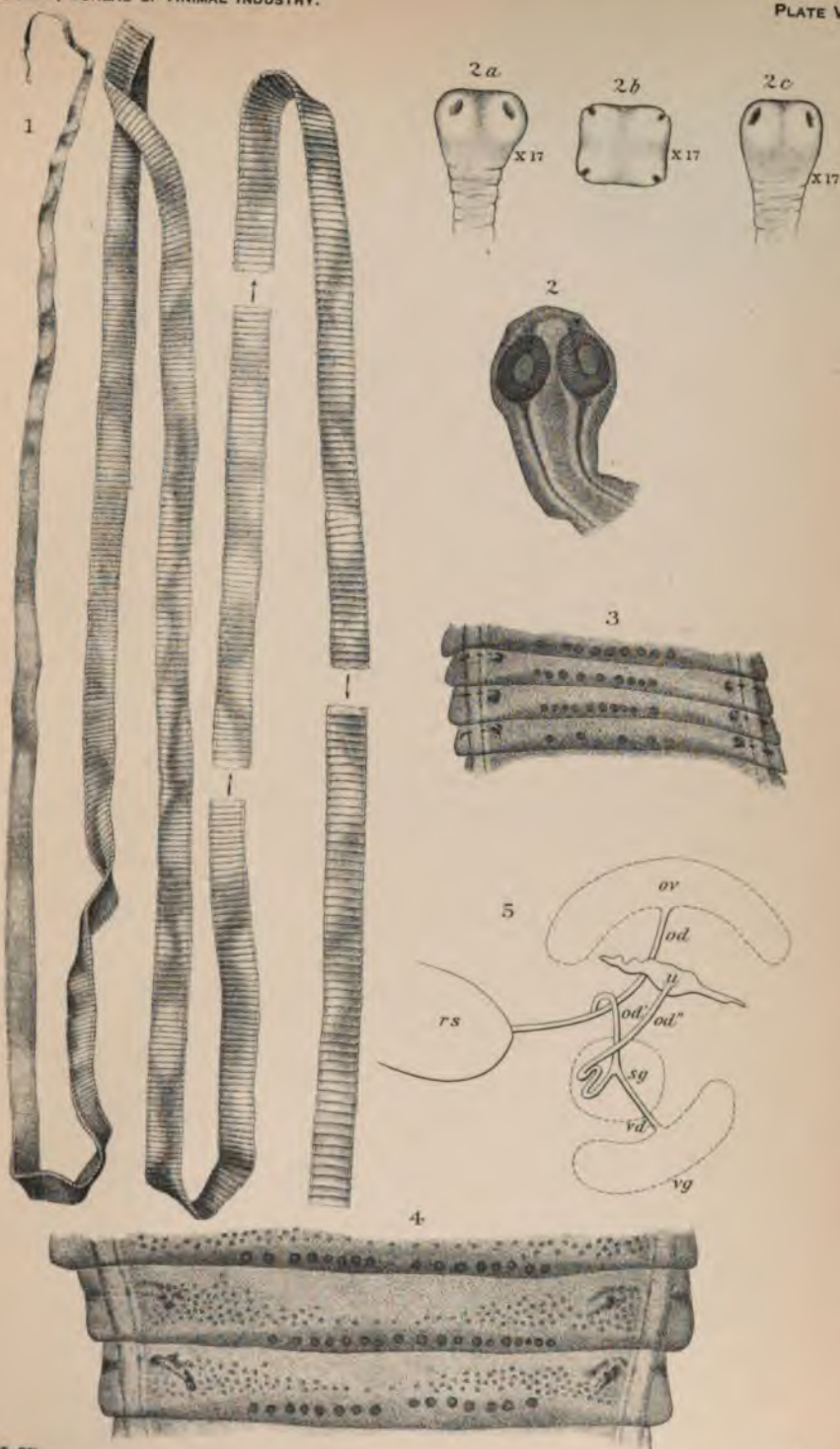
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PLATE VIII.—*Moniezia trigonophora*.

- Fig. 1. Strobila, natural size.
Fig. 2. Head, balsam preparation. $\times 17$.
Fig. 2a. Head, alcohol preparation, ventral view. $\times 17$.
Fig. 2b. The same, *en face*. $\times 17$.
Fig. 2c. The same, lateral view. $\times 17$.
Fig. 3. Segments 10^m from anterior extremity.
Fig. 4. Segments 30^m from anterior extremity.
Fig. 5. Diagram of female glands and canals, dorsal view.



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MONIEZIA TRIGONOPHORA

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PLATE IX.—*Moniezia trigonophora*.

Fig. 1. Sagittal section of a sac around which the cells of the interproglottidal gland are grouped.

Fig. 2. The same, frontal section.

Fig. 3. Diagram of the female glands and canals, transverse section.

Fig. 4. Segment 60^{cm} from the anterior extremity, showing all the organs except the uteri, which have not yet developed. Ventral view.

Fig. 5. Segments with developing uteri; a space is left vacant in the median line.

Fig. 6. Segments with fully developed uteri and eggs.



PLATE X.—*Moniezia alba*.

Figs. 1-2*b*, from Perroncito's original material.

Fig. 1. Strobila, natural size; a, head and anterior portion of one specimen; b-n from a specimen 1^m 40^{cm} long, lacking head; b, anterior portion; c, 10^{cm} from anterior end; d 20^{cm}, e 30^{cm}, f 40^{cm}, g 50^{cm}, h 70^{cm}, i 80^{cm}, j 90^{cm}, k 100^{cm}, l 110^{cm}, m 120^{cm}, n 130^{cm}, from anterior extremity.

Fig. 2. Head, lateral view. × 17.

Fig. 2*a*. Head, ventral view. × 17.

Fig. 2*b*. Head, viewed *en face*. × 17.

Figs. 3-7 from Neumann's specimen.

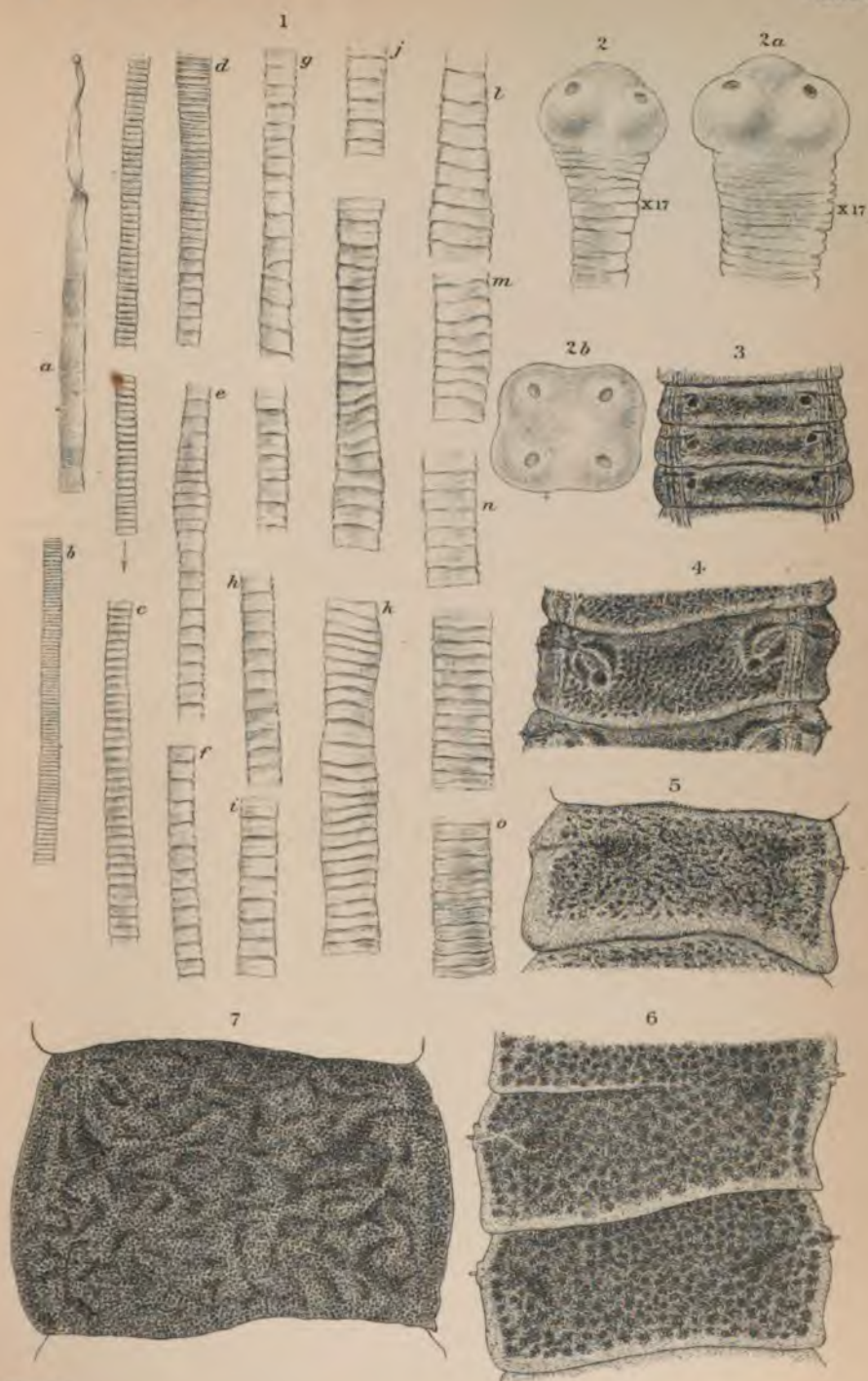
Fig. 3. Segments 10^{cm} from the head, 2^{mm} wide.

Fig. 4. Segments 32^{cm} from the head, 3^{mm} wide.

Fig. 5. Segments 55^{cm} from the head, 4^{mm} wide.

Fig. 6. Segments 79^{cm} from the head, 4^{mm} wide.

Fig. 7. Segments 1^m from the head, 5.5 wide by 3^{mm} long.



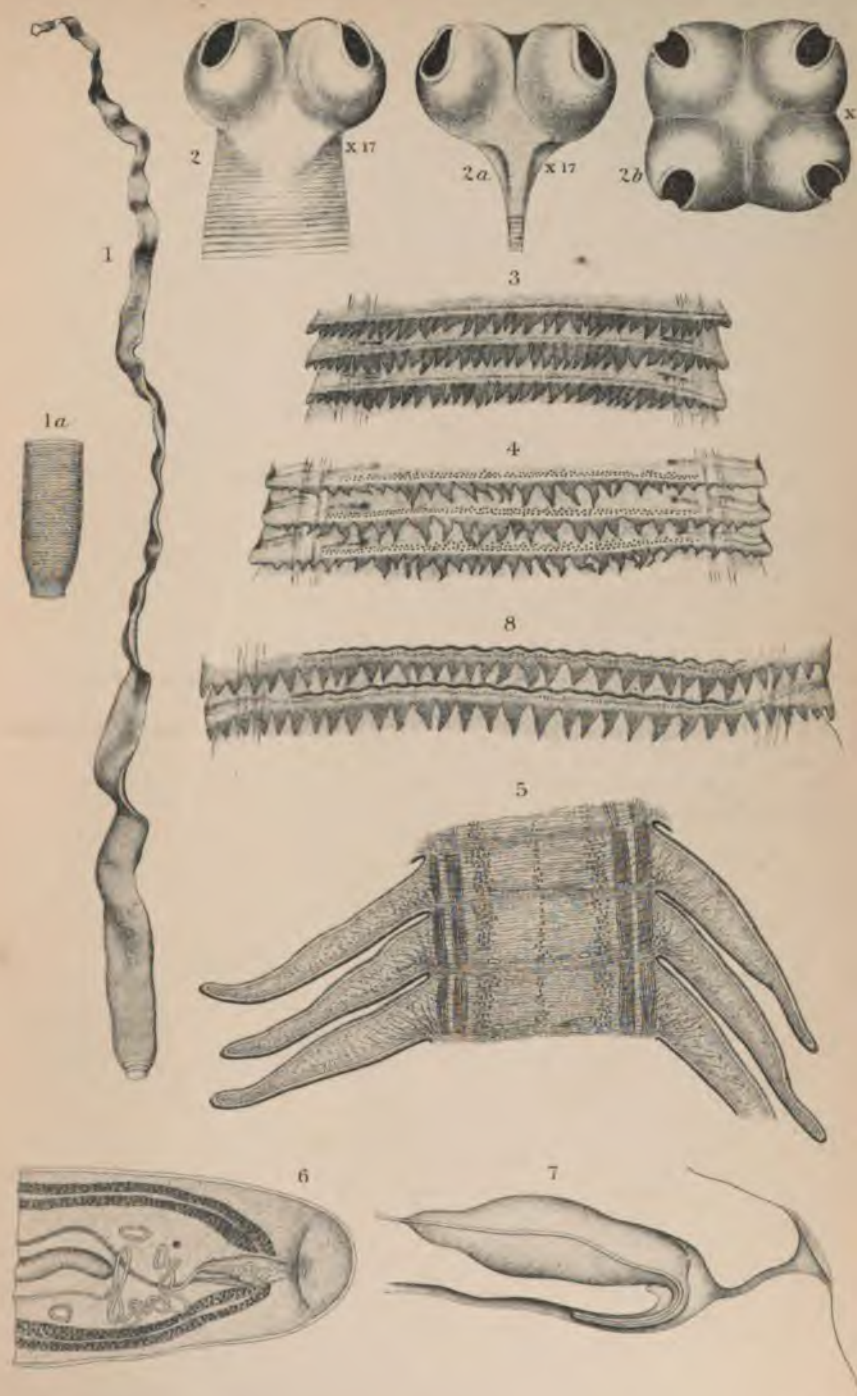
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MONIEZIA ALBA

PLATE XI.—*Thysanosoma actinioides*.

- Fig. 1. Strobila, natural size.
Fig. 1a. End portion of another strobila.
Fig. 2. Head, ventral view. $\times 17$.
Fig. 2a. The same, lateral view. $\times 17$.
Fig. 2b. The same, *en face*. $\times 17$.
Fig. 3. Segments 60^{mm} from the head.
Fig. 4. Segments 100^{mm} from the head, showing testicles and genital canals.
Fig. 5. Sagittal section showing two transverse canals.
Fig. 6. Transverse section showing topography of the genital and longitudinal canals.
Fig. 7. Cirrus in copulation.
Fig. 8. Segment with uterus.



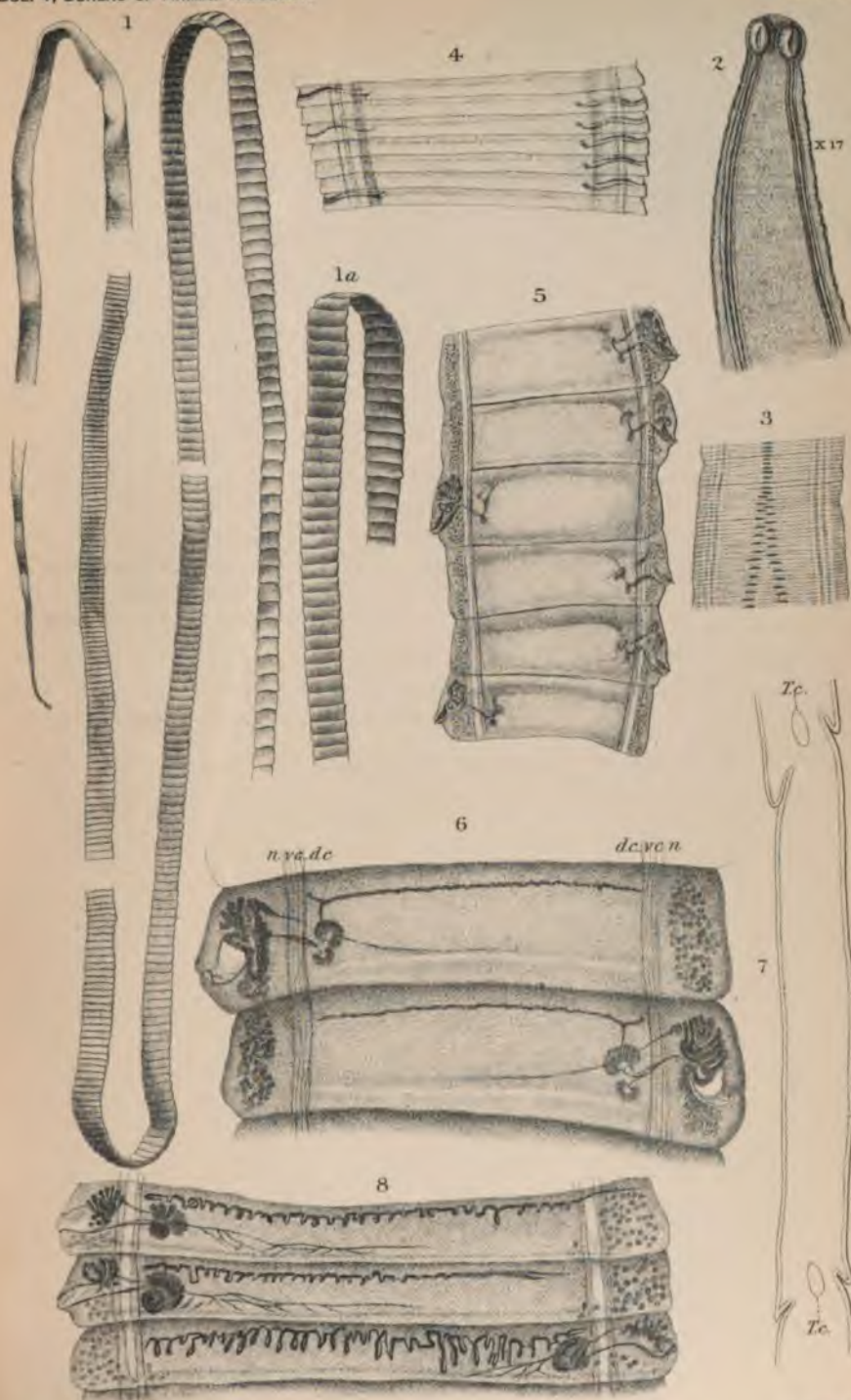
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THYSANOSOMA ACTINIODES

PLATE XII.—*Thysanosoma Giardi*.

- Fig. 1. Strobila, natural size; head drawn from a separate fragment.
Fig. 1a. Fragment, with larger segments, natural size.
Fig. 2. Head probably of *Th. Giardi*, balsam preparation. $\times 17$.
Fig. 3. Strobila belonging to head in Fig. 2. The genital anlage is at first in the median line, then diverges towards the right and left in alternate segments.
Fig. 4. Segments with pistol-shaped anlage of the genital canals. One segment has an extra male canal. Dorsal view.
Fig. 5. Six segments with developing genital organs. Dorsal view.
Fig. 6. Genital organs well developed. Dorsal view. See Fig. 5, Plate VII.
Fig. 7. Sagittal section showing the proportion of length to thickness. T. c. transverse canal.
Fig. 8. Three segments showing the wavy appearance of the uterus.



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THYSANOSOMA GIARDI

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PLATE XIII—*Thysanosoma Giardi*.

Fig. 1. Three segments, ventral view. The second segment has double genital pores.

Fig. 2. Segments with well-developed uterus. The other genital organs are atrophying. Dorsal view.

Fig. 3. Segment with fully-developed uterus. The other genital organs are almost entirely atrophied.

Fig. 4. Egg-sacs developing.

Fig. 5. Fully developed egg-sacs.



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THYSANOSOMA GIARDI

PLATE X.—*Moniezia alba*.

Figs. 1-2*b*, from Perroncito's original material.

Fig. 1. Strobila, natural size; a, head and anterior portion of one specimen; b-n from a specimen 1^m 40^m long, lacking head; b, anterior portion; c, 10^{cm} from anterior end; d 20^{cm}, e 30^{cm}, f 40^{cm}, g 50^{cm}, h 70^{cm}, i 80^{cm}, j 90^{cm}, k 100^{cm}, l 110^{cm}, m 120^{cm}, n 130^{cm}, from anterior extremity.

Fig. 2. Head, lateral view. × 17.

Fig. 2*a*. Head, ventral view. × 17.

Fig. 2*b*. Head, viewed *en face*. × 17.

Figs. 3-7 from Neumann's specimen.

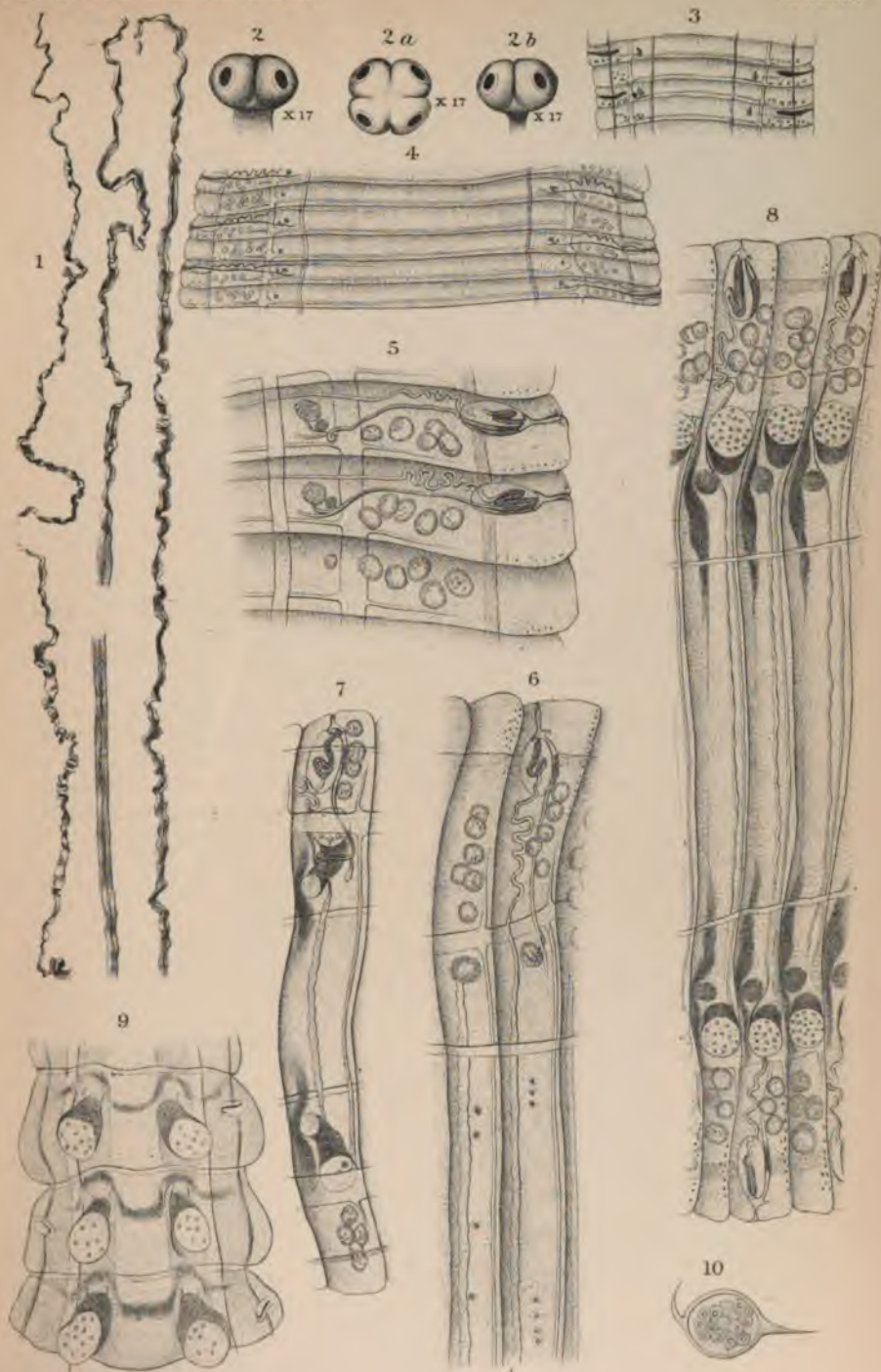
Fig 3. Segments 10^{cm} from the head, 2^{mm} wide.

Fig. 4. Segments 32^{cm} from the head, 3^{mm} wide.

Fig. 5. Segments 55^{cm} from the head, 4^{mm} wide.

Fig. 6. Segments 79^{cm} from the head, 4^{mm} wide.

Fig. 7. Segments 1^m from the head, 5.5 wide by 3^{mm} long.



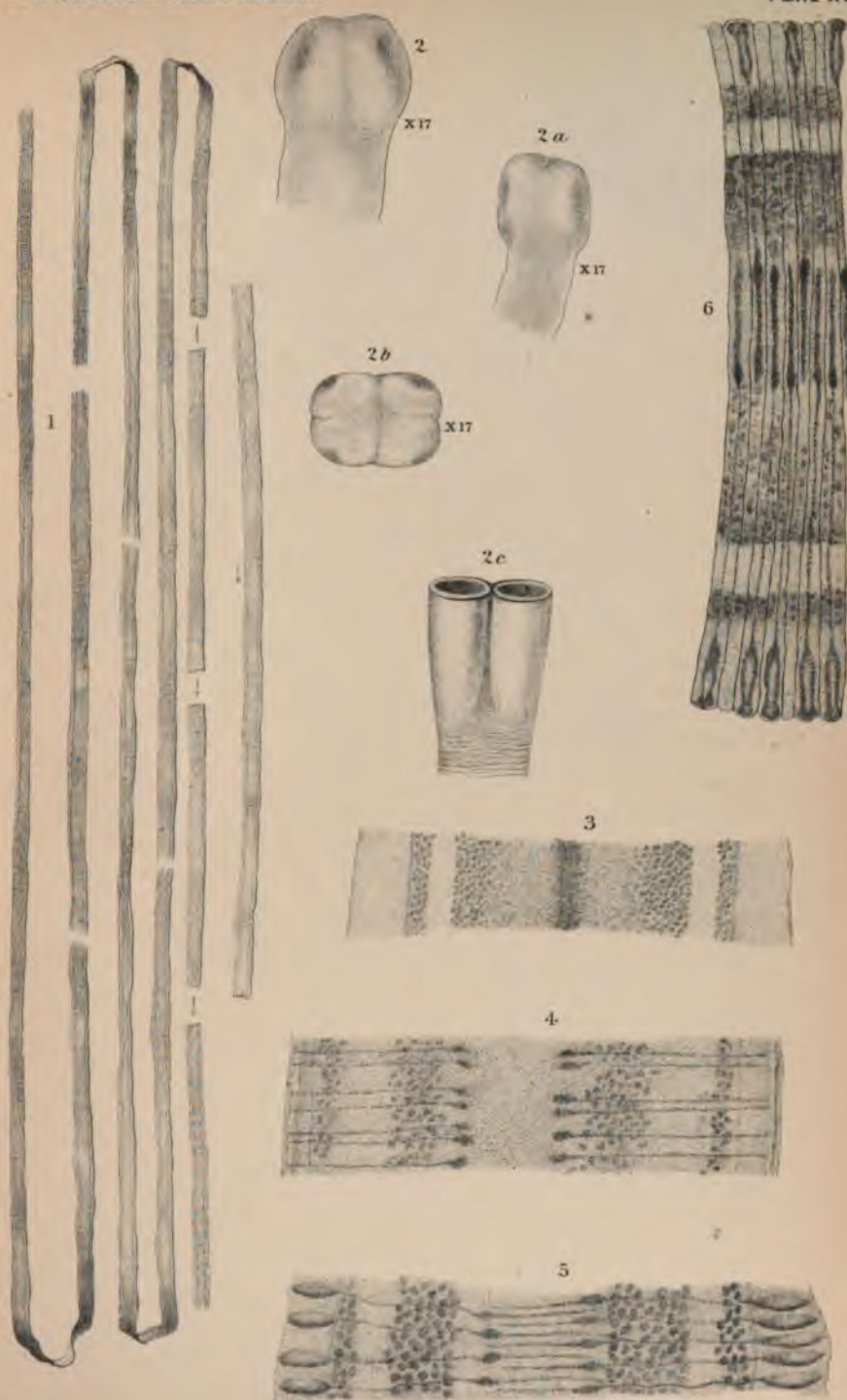
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STILESIA GLOBIPUNCTATA

PLATE XI.—*Thysanosoma actinioides*.

- Fig. 1. Strobila, natural size.
Fig. 1a. End portion of another strobila.
Fig. 2. Head, ventral view. $\times 17$.
Fig. 2a. The same, lateral view. $\times 17$.
Fig. 2b. The same, *en face*. $\times 17$.
Fig. 3. Segments 60^{mm} from the head.
Fig. 4. Segments 100^{mm} from the head, showing testicles and genital canals.
Fig. 5. Sagittal section showing two transverse canals.
Fig. 6. Transverse section showing topography of the genital and longitudinal canals.
Fig. 7. Cirrus in copulation.
Fig. 8. Segment with uterus.



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STILESIA CENTRIPUNCTATA

PLATE XVI.—*Moniezia, species inquirenda.*

Figs. 1-2*b*. Bureau collection, specimen No. 607, borrowed from Hassall's private collection, collected in England.

Fig. 1. Segments, natural size.

Fig. 1*a*. Segments. $\times 3$.

Fig. 2. Head, viewed *en face*, alcohol specimen, much contorted. $\times 17$.

Fig. 2*a*. The same, ventral view. $\times 17$.

Fig. 2*b*. The same, lateral view. $\times 17$.

Figs. 3, 3*a*. Head of Moniez's specimen of *M. nullicollis*.

Fig. 3. Head, lateral view. $\times 17$.

Fig. 3*a*. The same, ventral view. $\times 17$.

Fig. 3*b*. The same, *en face*. $\times 17$.

Figs. 4, 4*b*. Bureau collection, No. 725, *Moniezia* sp., *Expansa* group.

Fig. 4. Head, ventral view. $\times 17$.

Fig. 4*a*. The same, lateral view. $\times 17$.

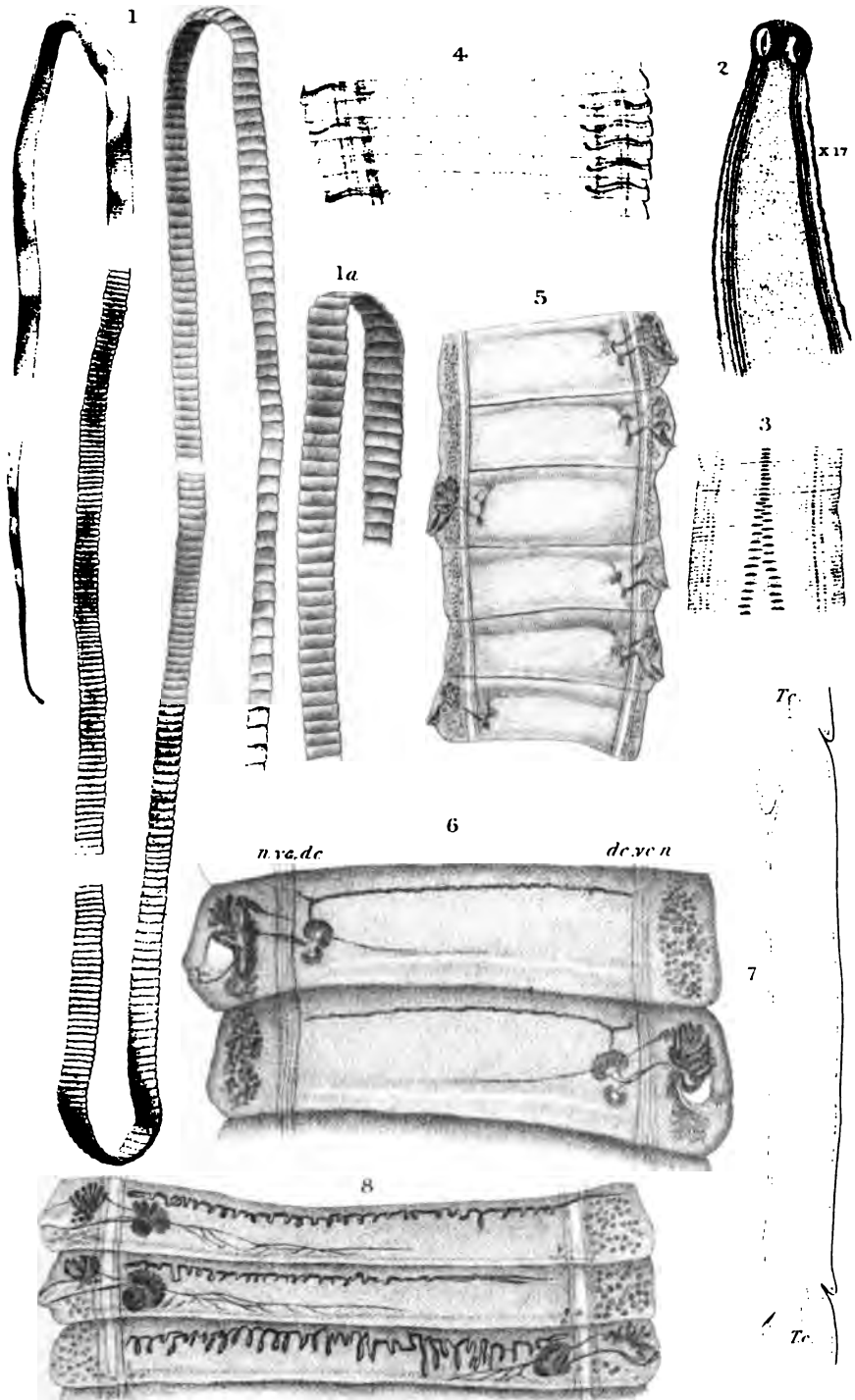
Fig. 4*b*. The same, *en face*. $\times 17$.

Figs. 5, 5*a*. Bureau collection, No. 612, *Moniezia* sp., *Planissima* group.

Fig. 5. Head, ventral view. $\times 17$.

Fig. 5*a*. The same, *en face*. $\times 17$.

Fig. 6 and 6*a*. A head found in sheep. Possibly the same as B. A. I. collection No. 612.



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THYSANOBOMA GIARDI

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PLATE XIII—*Thysanosoma Giardi*.

Fig. 1. Three segments, ventral view. The second segment has double genital pores.

Fig. 2. Segments with well-developed uterus. The other genital organs are atrophying. Dorsal view.

Fig. 3. Segment with fully-developed uterus. The other genital organs are almost entirely atrophied.

Fig. 4. Egg-sacs developing.

Fig. 5. Fully developed egg-sacs.



PLATE XIV.—*Stilesia globipunctata*.

Fig. 1. Strobilæ, fragments, natural size.

Fig. 2, 2b. Scolex, viewed ventrally, *en face* and from the side. $\times 17$.

Fig. 3. Segments 15^{mm} from head, showing nerves, canals and anlagen of genital organs; dorsal view. About 56 μ long by 0.57^{mm} broad.

Fig. 4. Segments 27-50^{mm} from head; the anlagen of the uteri are present; dorsal view. About 96 μ long by 1.14^{mm} broad.

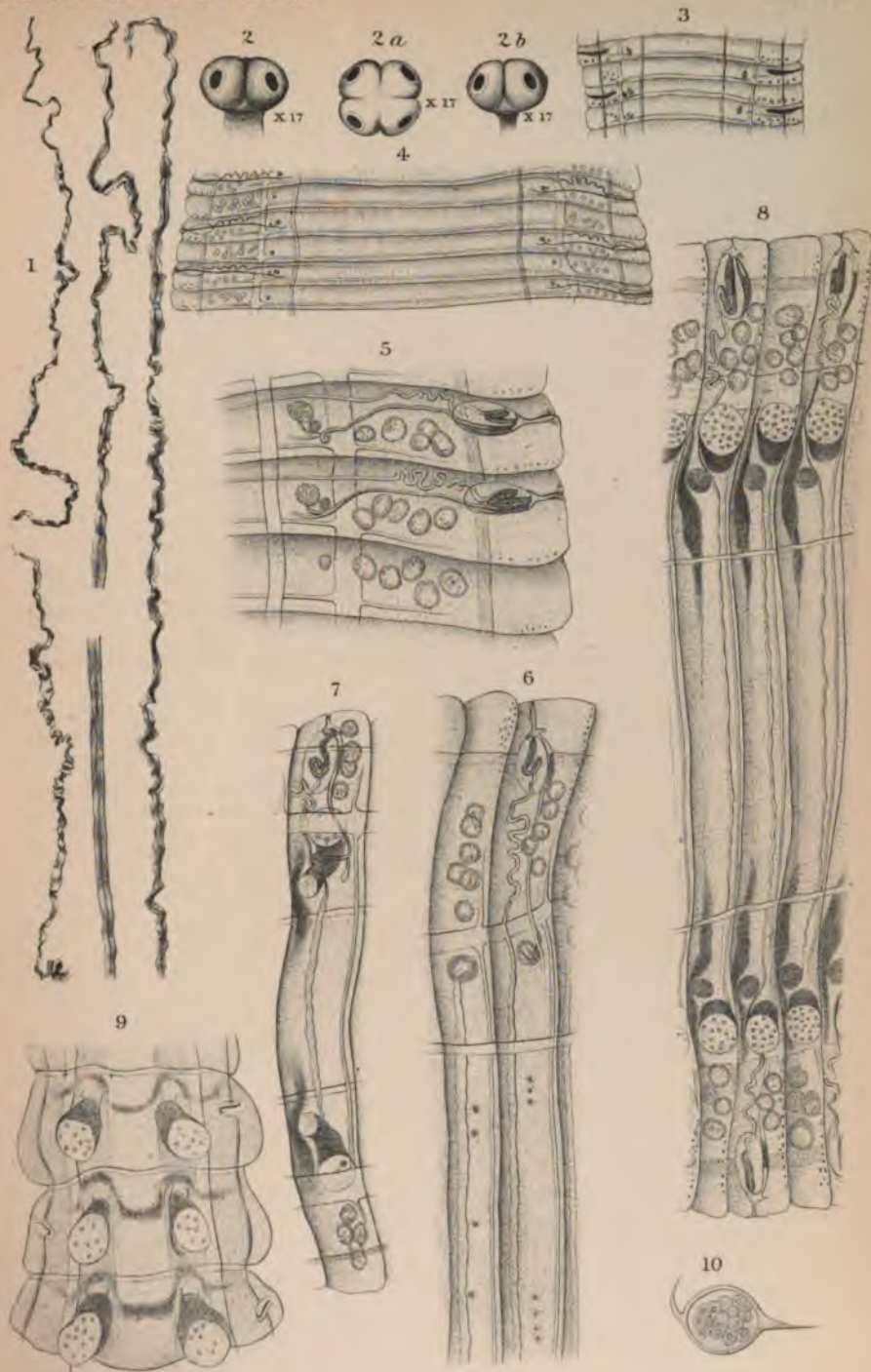
Fig. 5. End of same, greatly enlarged.

Fig. 6. Right end of slightly older segments, showing ova in the median field; dorsal view.

Figs. 7 and 8. Segments showing two stages of the uterus and transverse organ; fig. 7, ventral view; fig. 8, dorsal view; in fig. 7 the ovary is still visible. Fig. 7, about 0.16^{mm} by 1.4^{mm}; fig. 8, about 0.13^{mm} by 2.3^{mm}.

Fig. 9. End segments. About 0.26^{mm} by 0.64^{mm}.

Fig. 10. Egg. Zeiss $\frac{1}{2}$ in.



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STILESIA GLOBIPUNCTATA

1

PLATE XV.—*Stilesia centripunctata*.

Fig. 1. Portion of a strobila, natural size.

Fig. 2. Head, ventral view. $\times 17$.

Fig. 2*a*. Head, lateral view. $\times 17$.

Fig. 2*b*. Head, *en face*. $\times 17$.

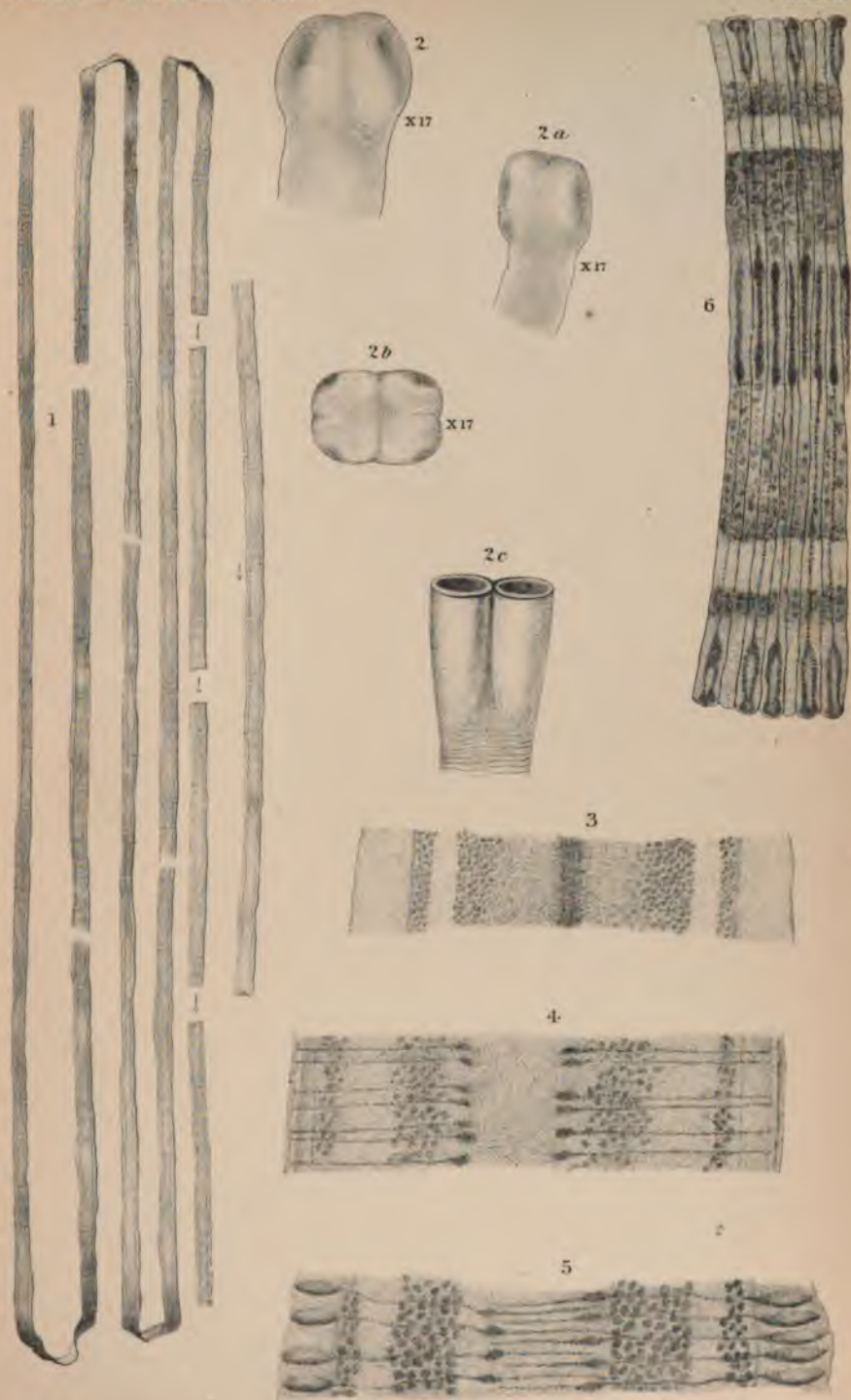
Fig. 2*c*. Head, after Neumann.

Fig. 3. Segments 1^{mm} broad.

Fig. 4 Segments 1.12^{mm} broad.

Fig. 5. Segments 1.24^{mm} broad.

Fig. 6. Segments 1.6^{mm} broad.



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STILESIA CENTRIPUNCTATA

PLATE XVI.—*Moniezia*, species inquirenda.

Figs. 1-2b. Bureau collection, specimen No. 607, borrowed from Hassall's private collection, collected in England.

Fig. 1. Segments, natural size.

Fig. 1a. Segments. $\times 3$.

Fig. 2. Head, viewed *en face*, alcohol specimen, much contorted. $\times 17$.

Fig. 2a. The same, ventral view. $\times 17$.

Fig. 2b. The same, lateral view. $\times 17$.

Figs. 3, 3a. Head of Moniez's specimen of *M. nullicollis*.

Fig. 3. Head, lateral view. $\times 17$.

Fig. 3a. The same, ventral view. $\times 17$.

Fig. 3b. The same, *en face*. $\times 17$.

Figs. 4, 4b. Bureau collection, No. 725, *Moniezia* sp., *Expansa* group.

Fig. 4. Head, ventral view. $\times 17$.

Fig. 4a. The same, lateral view. $\times 17$.

Fig. 4b. The same, *en face*. $\times 17$.

Figs. 5, 5a. Bureau collection, No. 612, *Moniezia* sp., *Planissima* group.

Fig. 5. Head, ventral view. $\times 17$.

Fig. 5a. The same, *en face*. $\times 17$.

Fig. 6 and 6a. A head found in sheep. Possibly the same as B. A. I. collection No. 612.

PLATE XVI.—*Moniezia*, species inquirendo.

Figs. 1-2b. Bureau collection, specimen No. 607, borrowed from Hassall's private collection, collected in England.

Fig. 1. Segments, natural size.

Fig. 1a. Segments. $\times 3$.

Fig. 2. Head, viewed *en face*, alcohol specimen, much contorted. $\times 17$.

Fig. 2a. The same, ventral view. $\times 17$.

Fig. 2b. The same, lateral view. $\times 17$.

Figs. 3, 3a. Head of Moniez's specimen of *M. nullicollis*.

Fig. 3. Head, lateral view. $\times 17$.

Fig. 3a. The same, ventral view. $\times 17$.

Fig. 3b. The same, *en face*. $\times 17$.

Figs. 4, 4b. Bureau collection, No. 725, *Moniezia* sp., *Expansa* group.

Fig. 4. Head, ventral view. $\times 17$.

Fig. 4a. The same, lateral view. $\times 17$.

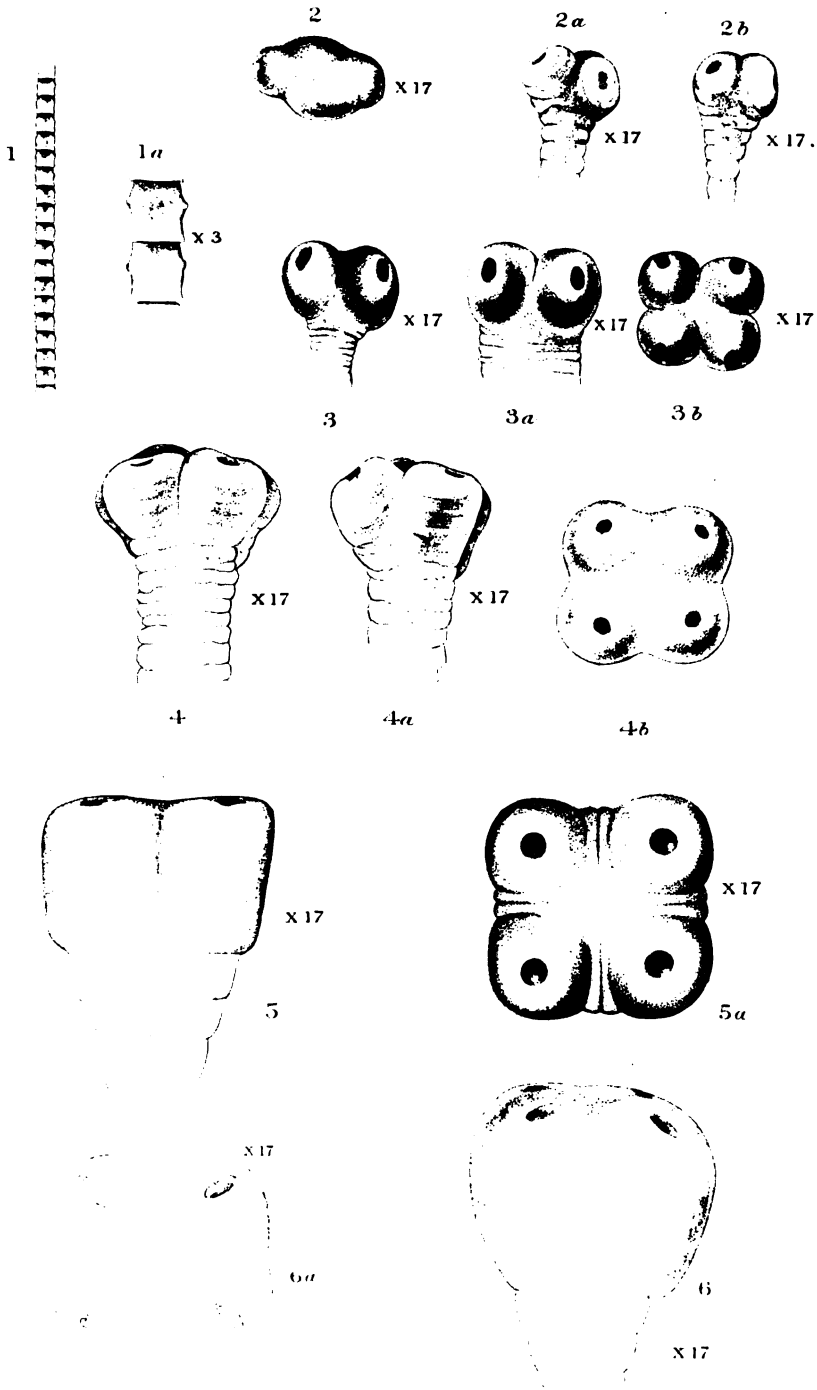
Fig. 4b. The same, *en face*. $\times 17$.

Figs. 5, 5a. Bureau collection, No. 612, *Moniezia* sp., *Planissima* group.

Fig. 5. Head, ventral view. $\times 17$.

Fig. 5a. The same, *en face*. $\times 17$.

Fig. 6 and 6a. A head found in sheep. Possibly the same as B. A. I. collection No. 612.



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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF ANIMAL INDUSTRY.

BULLETIN No. 5.

REPORT

ON THE

DAIRY INDUSTRY

OF

DENMARK

BY

Prof. C. C. GEORGESON.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

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1893.



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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., September 6, 1893.

SIR: I have the honor to transmit herewith for publication the report of Prof. C. C. Georgeson upon his recent investigations of the dairy industry of Denmark.

Very respectfully,

D. E. SALMON,
Chief of Bureau of Animal Industry.

Hon. J. STERLING MORTON,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

KANSAS STATE AGRICULTURAL COLLEGE,
Manhattan, Kansas, September 2, 1893.

SIR: I have the honor to submit herewith my report on the dairy industry of Denmark, which, under date of January 7, 1893, I was instructed to investigate under the auspices of your Bureau.

Very respectfully,

C. C. GEORGESON.

Dr. D. E. SALMON,
Chief of Bureau of Animal Industry.

REPORT ON THE DAIRY INDUSTRY OF DENMARK.

By C. C. GEORGESON.

INTRODUCTORY.

The facts hereinafter detailed were gathered during my recent visit to Denmark as a special agent of the U. S. Department of Agriculture. I was commissioned by Hon. J. M. Rusk, in January last, for a period of two months, afterwards extended by thirty days, making the time three months in all. I deem it but just to say that the short time at my disposal for the trip and the unfavorable season of the year when it was made—it being midwinter—prevented my investigation from being as thorough as it would have been under more favorable circumstances.

The following quotation from my instructions makes plain the object of my visit:

I desire that your investigations should cover the three phases of the dairy industry, namely: First, the dairy farm, including the subject of breeds, yield per animal, feeding, general care, and the disposal and handling of the milk; second, the manufacture of dairy products, its methods and appliances; and third, the trade in dairy products, the value of butter and cheese in the home market and at ports of shipment, and other statistics showing the extent and distribution of dairy products and the various characteristics as to form, color, salting and packing, etc., required to meet the wants of foreign countries. You will proceed at once to Denmark to undertake this work and will complete it in the shortest time possible, returning directly to Washington (via London and Liverpool) to prepare and submit your report.

I arrived in Denmark on the 27th of January and left again on the 6th of March. The interval between these dates I spent in visiting representative creameries and dairy farms on three of the islands and on the peninsula, and I also made it a point to meet as many as possible of the men, both scientific and practical, who are identified with the development of the dairy industry. Among those to whom I am indebted for valuable information I would especially mention Prof. T. R. Segeleke and Prof. V. Storch, the former of the Royal Agricultural College at Copenhagen, and the latter of the Experimental Laboratory, same place; Konsulent B. Bóggild, Secretary of the Royal Agricultural

Society, also of Copenhagen; Konsulent J. N. Dall, of Fredericia; Konsulent A. Apple, of Aarhus, and Mr. E. A. Quist, of Skanderborg.

I am also indebted to a large number of dairy managers and farmers, some of whom will be mentioned hereafter, for information in regard to their individual methods in the dairy and on the farm.

I was everywhere courteously received. Although my presence on such a mission gave rise to a natural and freely expressed suspicion that perhaps the United States intended to compete with Denmark for favors in the English dairy market, this suspicion did not cause any secretiveness or unwillingness to give information. My many questions, which often concerned private business affairs, were in every instance answered cheerfully and satisfactorily. This much, by way of acknowledgment, is due to the many who, by their unstinted readiness to give information, met me more than half way and enabled me to collect the facts here presented.

The agricultural, and especially the dairy, literature of Denmark has been another rich source of information. I have perused no small number of publications of this character, first among which should be mentioned a work on the dairy by Bernhard Bøggild, entitled "Mælkeribruget i Danmark." The others are mostly pamphlets and reports issued by agricultural societies, and statistical works published by the Danish Government. Among the most important I may name the bulletins of the agricultural experiment station at Copenhagen, the reports of the official "Konsulenter" (advisers) in matters pertaining to dairy and stock-breeding, and publications by the Royal Danish Agricultural Society.

FACTS ABOUT DENMARK.

SITUATION.

A glance at the accompanying map (Fig. 1) shows that Denmark is almost entirely surrounded by water. It lies far to the north, being between $54^{\circ}30'$ and $57^{\circ}30'$ north latitude and between 8° and $12^{\circ}45'$ east longitude. The climate belonging to this latitude is, however, materially modified by the large body of water surrounding the country, so that the extremes of temperature are really not so great there as they are on the adjoining continent, farther south. The map also shows the situation of the leading cities and the lines of railroad. The heavy double line across the neck of the peninsula is the German frontier. On the west coast, just above this line, will be noticed the port of Esbjerg. This port has sprung into importance during the last few years, and grown in population with phenomenal rapidity, solely because the establishment of a steamship line from this port to England has made it the port of shipment for nearly all the Danish butter going to that country.

AREA, SOILS, AND CLIMATE.

The area of Denmark is 14,553 English square miles, which is less than one-tenth the size of the State of California or about half the size of the State of Maine. The population, in round numbers, is 2,000,000 people, giving 137 persons to the square mile. The topographical features are not striking; there are no mountains at all in the country and the hills are not high. On the islands the land is generally undulating, with here and there a ridge of hills which range somewhat higher than the average. On the peninsula occur several long



FIG. 1.—Map of Denmark.

stretches of level ground, portions of which consist chiefly of drift sand and are overgrown with heather. These tracts are, of course, unsuited for agriculture. The soil is varied in character. In many places it is clayey and in others it is very sandy. This variation is due chiefly to glacial action, which is everywhere evident. The clay soil is, as a rule, fertile but difficult to work; the sandy soil, on the other hand, requires constant addition of fertilizers in order to produce paying crops. The

climate is moist, although the rainfall is not excessive; but there are frequent storms of light misty rains which last sometimes for days, and fog and mist are very frequent, especially during the winter. The snowfall is variable, but, as a rule, the snow lies on the ground so as to furnish sleighing for two or three months each winter, and in some years much longer.

TEMPERATURE AND RAINFALL.

The average temperature for the three winter months ranges from 31.1° to 34.7° F; for the spring months, from 40.1° to 43.7° ; for the summer months, from 57.2° to 61.7° ; and for the fall months from 44.6° to 49.1° , the average for the whole year being from 43.7° to 47.3° .

The rainfall averages about as follows: For the winter months, 5 inches; for the spring months, 4 inches; for the summer months, 6.8 inches; and for the fall months, 8 inches. This seems to be a light rainfall, but it should be borne in mind that in that far northern latitude evaporation does not take place so rapidly as it does in nearly all parts of the United States, and hence a greater proportion of the rain can go to the direct benefit of the crops. Complete failure of crops on account of drought never occurs, and there is rarely a deficiency in the crops from lack of rainfall.

CONDITION OF AGRICULTURE.

Agriculture is prosperous, but its present condition has been reached only through a gradual improvement which began a century ago. At that time the peasants, the cultivators of the soil, owned but a very small proportion of the land they cultivated; it was nearly all in the hands of landlords. Since then the latter have gradually sold to the peasants a large proportion of the land, and now somewhat more than 50 per cent of the area under cultivation is owned by peasant farmers, and of the remaining land the greater portion is worked by them under a system of life tenancy by which the farm will sometimes remain in the same family for several generations, the contract being renewed by the son on the death of his father. A farmer, for example, desires to rent a farm which is tenantless. He agrees to pay so much in annual rent, in addition to which a certain sum is always paid down at the time the bargain is made. He begins to work the place, and continues to work it unmolested as long as he lives and his wife after him, if he dies before she does, but if she marries again the old contract is abrogated and a new one is made with the incoming farmer. This plan is the most satisfactory arrangement that can be made, next to ownership of the lands. The farmer feels that he is secure in reaping whatever benefits may accrue from his improvements. He can drain his land, or fence it, sub-soil it, and manure it without the fear that his rent will

be increased or that he will be turned off and some one else will take the place.

A limited number of farms are rented from year to year, according as the parties concerned can agree. There are in the country quite a number of large farms ranging from 500 acres to 1,500 or upwards. These are, as a rule, owned by the families of the old-time landlords who in former days owned all of the surrounding country. They seldom work these large farms themselves, but rent them to tenants, who usually pay as high a rent as the farms warrant, leaving but a small margin for the farmer. He tries to widen this marginal profit by improved methods of culture and economic handling and sale of his crops. In these cases the lease usually lasts for a series of years, the number varying with the system of rotation in vogue, it being so arranged that the farmer can take one of each of the crops in the rotation from each field. Thus in an eight-year rotation the farm will be divided into eight fields and the lease run for eight years at so much per year.

FARM CROPS AND THEIR CULTURE.

To get a correct idea of the relation which dairying bears to general farming it will be desirable to look briefly into the character of the farm crops, and the relative proportion in which they are grown.

The following tables have been deduced from "Danmarks Statistik," fourth series, Litra C, No. 7, and show how the soil of the whole kingdom was in use on the 16th of July, 1888. What changes have taken place in the cropping since that time have been in the direction of enlarged areas in fodder crops. I have reduced the figures to acres in order to make the statements more intelligible to American readers:

Acres seeded in Denmark in 1888.

Kind of crop.	On the islands.		On the peninsula of Jutland.		Total area.	
	Acres.	Per cent of area seeded.	Acres.	Per cent of area seeded.	Acres.	Per cent of total area seeded.
Wheat.....	98,214	6 $\frac{1}{2}$	18,760	1 $\frac{1}{2}$	116,974	3 $\frac{5}{100}$
Rye.....	230,130	16 $\frac{7}{10}$	439,876	23 $\frac{1}{2}$	679,006	20 $\frac{1}{2}$
Barley.....	422,314	29 $\frac{1}{2}$	298,119	16 $\frac{1}{2}$	720,433	22
Oats.....	311,922	21 $\frac{1}{2}$	718,269	38 $\frac{1}{2}$	1,030,191	31 $\frac{1}{2}$
Buckwheat.....	2,937	0 $\frac{1}{2}$	51,823	2 $\frac{1}{2}$	54,760	1 $\frac{5}{100}$
Field peas.....	24,592	1 $\frac{1}{2}$	7,457	0 $\frac{1}{2}$	32,049	0 $\frac{1}{10}$
Vetches.....	7,621	0 $\frac{1}{2}$	1,633	0 $\frac{1}{100}$	9,254	0 $\frac{2}{100}$
Field beans.....	421	0 $\frac{1}{100}$	33	0 $\frac{1}{1000}$	454	0 $\frac{1}{100}$
Oats and barley mixed:						
For the grain.....	139,757	9 $\frac{1}{2}$	85,128	4 $\frac{1}{2}$	224,885	6 $\frac{1}{2}$
For green fodder.....	67,154	4 $\frac{7}{10}$	34,800	1 $\frac{1}{10}$	101,954	3 $\frac{1}{100}$
Potatoes.....	40,018	2 $\frac{1}{2}$	86,304	4 $\frac{1}{2}$	126,322	3 $\frac{1}{100}$
Roots.....	71,005	5	56,876	3 $\frac{1}{10}$	127,881	3 $\frac{1}{10}$
Rape.....	794	0 $\frac{1}{100}$	1,332	0 $\frac{1}{100}$	1,126	0 $\frac{1}{100}$
Miscellaneous.....	3,568	0 $\frac{1}{2}$	1,921	0 $\frac{1}{100}$	5,489	0 $\frac{1}{100}$
Spurrey and lupines.....	3,265	0 $\frac{1}{2}$	42,596	2 $\frac{1}{100}$	45,861	1 $\frac{1}{10}$
Total.....	1,432,712		1,843,927		3,276,639	

Area in grass in 1888.

	On the islands.		On the peninsula.		Total area.	
	Acres.	Per cent of grass land.	Acres.	Per cent of grass land.	Acres.	Per cent of total.
Tame pastures.....	395,749	33 $\frac{3}{4}$	1,380,149	57 $\frac{1}{10}$	1,775,898	48 $\frac{7}{10}$
Clover and grass cut for hay.....	296,152	25 $\frac{1}{2}$	143,829	6 $\frac{1}{10}$	439,981	12 $\frac{1}{10}$
Clover and grass for seed.....	4,632	0 $\frac{1}{2}$	2,985	0 $\frac{1}{10}$	7,617	0 $\frac{1}{10}$
Fallow.....	224,721	19 $\frac{1}{2}$	249,527	10 $\frac{1}{10}$	474,248	13
Half fallow.....	84,572	7 $\frac{1}{2}$	66,372	2 $\frac{1}{2}$	150,944	4 $\frac{1}{10}$
Permanent meadow.....	120,610	10 $\frac{1}{2}$	433,892	18 $\frac{1}{2}$	554,502	15 $\frac{1}{10}$
Commons.....	49,102	4 $\frac{1}{2}$	114,868	4 $\frac{1}{2}$	163,976	6 $\frac{1}{10}$
Total.....	1,175,544		2,391,622		3,567,166	

Area in miscellaneous uses in 1888.

Gardens.....	39,148	4 $\frac{1}{10}$	29,221	1 $\frac{3}{10}$	68,369	3 $\frac{3}{10}$
Forest plantations.....	300,520	31 $\frac{1}{10}$	247,771	16 $\frac{1}{10}$	747,961	33 $\frac{1}{10}$
Marshes and peat bogs.....	500,116	51 $\frac{1}{10}$	242,264	15 $\frac{1}{10}$	292,380	12 $\frac{1}{10}$
Heath land.....	16,228	1 $\frac{1}{10}$	768,707	50	784,935	34 $\frac{1}{10}$
Drift sand.....	2,860	0 $\frac{1}{10}$	95,399	6 $\frac{1}{10}$	98,259	4 $\frac{1}{10}$
Stony land.....	12,924	1 $\frac{1}{10}$	43,357	2 $\frac{1}{10}$	56,281	2 $\frac{1}{10}$
Building sites.....	32,174	3 $\frac{1}{10}$	32,764	2 $\frac{1}{10}$	64,938	2 $\frac{1}{10}$
Fences, roads, and water courses.....	65,161	6 $\frac{1}{10}$	79,166	5 $\frac{1}{10}$	144,327	6 $\frac{1}{10}$
Total.....	969,131		1,538,649		2,257,450	

Referring to these tables it will be noticed that a very large proportion of these crops is designed for feed.

GRAIN IMPORTS AND EXPORTS.

As a matter of fact Denmark does not produce breadstuffs enough for the consumption of her own people. The statistics of imports and exports issued by the Government for the year 1891 show that the following quantities of grain were imported over and above the export of the same articles:

	Busbels.
Wheat.....	500,000
Rye.....	41,177,176
Oats.....	2,325,500
Buckwheat.....	102,745
Peas and beans.....	114,798
Indian corn.....	2,102,208

The figures have been summarized and reduced to bushels for ease of comprehension by American readers. The last item, Indian corn, is used chiefly for feed for live stock; as yet only a small amount of corn is used as food for the people.

This shows that a considerable quantity of grain is imported for home consumption and indirectly confirms the prominence which is given to the dairy. Barley is the only grain the export of which exceeds the import. The export of barley amounts to about 1,500,000 bushels; these figures, it should be noted, are not for any single year, but they represent the average of the years 1887, 1888, 1889, 1890, and 1891.

SIZE OF THE FARMS.

Graded according to their size, the farms of Denmark may be put into three classes, which we may designate respectively as large, medium, and small farms. The average size of the farms of each of these classes is difficult to ascertain because the statistics do not give the area of the land belonging to each class. They are classified upon the basis of taxation according to the quality of the land. The present basis, which is called "hartkorn," was established in 1844, when all the lands were revalued. But knowing the total area and the number of farms, it is easy enough to ascertain the average size of the Danish farms. Thus, in 1888, there were in the country 1,954 large farms. The size of these will range between 500 and 1,500 acres. There were 71,778 medium-sized farms, the areas of which range from 50 to 500 acres, and there were 150,260 small farms ranging in size from a small patch up to 50 acres. Now the total area of the country, excluding forests and waste land, and taking only what is under actual culture and in grass, is 6,843,805 acres, which makes the average size of the farm 30.55 acres.

LIVE-STOCK STATISTICS.

The latest available statistics I have on the subject are for 1888. In this year there were in Denmark 1,459,527 head of cattle, 375,533 head of horses, 1,225,196 head of sheep, and 770,785 head of swine. This gives 1.67 horses, 6.51 head of cattle, 3.44 head of swine, and 5.47 head of sheep for the average farm of 30.55 acres. It should be borne in mind that in estimating the average much land has been counted in which, for various reasons, does not support any live stock at all, such as gardens, and it also includes all of the very poor land and land fit only for pasture, and poor at that. In fact, it includes land of every description which has any agricultural value. At this same rate a 160-acre farm should support 8.7 head of horses, 34 head of cattle, 28.6 head of sheep, and 18 head of swine.

ANNUAL OUTPUT OF DANISH BUTTER.

The output of dairy products during recent years from this little country has been astonishingly large. Statistics published by the Government show that during 1891 Denmark exported 91,455,262 Danish pounds of butter, which amounts to 100,600,788 pounds avoirdupois. This is, however, inclusive of what was imported into the country and exported again. A considerable amount of foreign butter is imported and consumed there, presumably in order to save for export the more valuable Danish product. The total import of butter for 1891 amounted to 24,277,557 pounds avoirdupois. If we deduct the total imports from the total exports we get a surplus of 76,323,231 pounds avoirdupois as the product of the Danish creameries exported in 1891; but it appears from the statistics that of the total import of butter,

17,870,456 Danish pounds were destined for home consumption. Subtracting this from the total imports we have left 4,200,051 Danish pounds (4,620,056 pounds avoirdupois) of the import which was again exported. Now, if we subtract this small amount from the total export we shall get the actual amount of Danish-made butter which was put upon the foreign market in 1891, and this, it will be seen, amounts to 95,980,732 pounds avoirdupois. There are no statistics to throw light on the amount of butter which is annually consumed in the country, but it must be considerable. Bread and butter form an important part of the diet of the people. All through the spring and summer, from March to November, it is customary among the farmers and working classes to eat a lunch of bread and butter and cold meat or cheese in the middle of the forenoon, and another in the middle of the afternoon. And at the three regular meals of breakfast, dinner, and supper, bread and butter are, as a rule, also eaten freely. And this aside from what is used in cooking. In two cases in which I obtained data on this point I found that the family and help, in each case averaging about nine persons throughout the year, consumed annually at home about 660 pounds of butter. This would be an allowance of about 70 pounds to each person for the year, which seems high; but I believe it would not be too high an estimate if we should put the home consumption at 1.1 pounds per capita per week, or 55 pounds per year. The population may be reckoned at 2,000,000 in round numbers, though it is somewhat in excess of this (the census of 1890 puts the population at 2,172,205). The annual home consumption of butter would therefore amount to 110,000,000 pounds avoirdupois. On this estimate, as a basis, it is possible to approximate the total annual output of butter from the Danish dairies by a simple process of addition and subtraction. But first we should note that the consumption of oleomargarine is considerable, which, of course, goes to set free at least an equal amount of butter for export. The amount of oleomargarine imported in 1891 was 1,931,461 pounds, and the amount of same material produced at home 13,339,984 pounds; total, 15,271,445 pounds. The amount exported of this material was very slight—in round numbers, 500,000 pounds. This leaves a total of 16,248,589 pounds avoirdupois. The account stands as follows in pounds avoirdupois:

	Pounds avoirdupois.
Estimated home consumption.....	110,000,000
Less total import of butter.....	24,277,557
Less total consumption of oleomargarine.....	16,248,589
	40,526,146
Danish-made butter consumed at home.....	69,473,854
Total export of butter.....	100,600,788
Total annual production.....	170,074,642

This is done in a country less than one-tenth the size of the State of *California* and but little more than one-sixth the size of the State of

Kansas. It is an interesting study and in line with the purposes of this report to consider how such results have been attained. An output so large would not be possible if it were not for a conjunction of favorable conditions, which makes Denmark a natural dairy country.

DEVELOPMENT OF THE DAIRY.

The growth of the dairy has been slow, and it is only recently that it has reached the present high standard. Some ninety or one hundred years ago the dairy was of little consequence except on the large farms; the smaller farms did well if they could keep the family in butter. It was not unfrequently the case that a farmer kept more horses than cattle, and the cattle received but poor treatment. They frequently had to seek their food from early spring until the snow fell, without any grain whatever, and when stabled in winter they were kept alive on straw and a little hay, the object being simply to winter them until they could again be turned to grass in the spring. Under these conditions they gave, of course, but little milk.

On the large farms the agriculture was, as a rule, farther advanced. The owners were well-to-do people of education who kept abreast of the times, and they generally employed competent superintendents for their farms. Their live stock was, therefore, of a better quality than that owned by the small farmers; still, there was but little interest shown in the dairy. Steer-feeding, on the other hand, was an important industry, and every farm raised and fattened for market a number of steers commensurate with the size of the farm. The Duchy of Holstein, which at that time belonged to Denmark, was the region where the dairy first developed, and somewhat later the island of Funen followed the same example. It was in these two districts that butter was first made for export and for the supply of the larger towns. The butter from Holstein held the first place and realized the best price in the market. Twelve cents a pound was at that time considered a fair price for butter.

The priests hold their parishes by the appointment of the Government, and to each country church a farm is attached for the support of the priest. These gentlemen were often the leaders not only in spiritual matters, but also in improved farming, and they, as a class, did their best to interest the farmers in the dairy and in the improvement of their live stock. Not a few of them have written instructive works on the subject. The political situation, in the beginning of this century, was unfavorable to the development of industries of any kind, but, as the troubles subsided, farming gradually improved, and it became more and more customary to employ skilled dairy women on the larger farms. These dairy people came from Holstein, and the methods they introduced were those practiced in their native districts. They had discovered that it was advantageous to keep the milk in a

low, even temperature, and for this purpose cellars were built under the dairy-houses, and the milk was strained in shallow wooden tubs or buckets only 4 or 5 inches deep, and these were placed upon the cold stone floor for the cream to rise. However, the whole treatment of the milk left much to be desired, and it was only during the summer, while the pastures were good, that there was a surplus of butter produced. The cows calved in the spring, and nearly all of them were dry during the greater part of the winter.

The Royal Agricultural Society was organized in 1769, with the object of advancing agriculture by every possible means. In the year 1837 this society undertook to provide instruction in dairying for the young and promising daughters of farmers. It was exclusively a practical course and covered two years, which time they spent on one and sometimes on two or even three of the largest farms in the country where dairying was recognized as an important branch of the farming. They participated in all kinds of work in the dairy and thus learned the business from thorough, practical experience. Those who had thus qualified themselves had no difficulty in obtaining positions on similar farms, as head dairy maids, where they had complete charge of the milk and butter and cheese-making. Cheese-making, however, never became an important branch of industry. It was only now and then that any attempts were made to make sweet-milk cheese, and as to skim-milk cheese it had no sale outside of the country; this branch of the dairy was naturally confined to the manufacture of cheese for home consumption. Butter, on the other hand, gradually grew in importance. That which was produced on the larger farms was sent to Hamburg and Keil for export to England, and the poorer grades were sent to Norway.

In the beginning of the '50's many of the smaller farmers had begun to take an interest in the dairy, and the merchants who handled the products began to send their butter directly to England instead of sending it by way of Hamburg or Keil, as formerly. In 1854 the Royal Agricultural Society undertook, for the first time, to provide practical instruction for young men in the dairy business, as they had already provided for the young women. The object was, however, mainly to train herdsmen and feeders, who with this united the trade of a cooper, and made the tubs and buckets and other wooden utensils required in the dairies, particularly the barrels in which the butter was transported to market. This departure proved successful, and even to the present day the same class of employees is kept on the larger farms. In 1858 the Royal Agricultural School, at Copenhagen, was started as a branch of the already existing veterinary school, and thus gradually the number of skilled helpers on the farm was increased.

This gradual advancement received further impetus by the example set by a few of the most enlightened landowners. These were, as a rule, large property-holders who had been well educated. *Etatsraad*

A. Valentiner and Gehjmekonferensraad E. Tesdorpf are examples of this class of leaders. By the improvements these and others like them made upon their farms, they set worthy examples for others to follow. Much of the advancement was also due to the direct teaching of a few specialists, who, through their published articles, their lectures, and their investigations of scientific questions called attention to improved systems in the treatment of the dairy cattle and of the milk. The most prominent of the latter class is Prof. Thos. R. Segelcke, who has spent upwards of thirty years in continued work for the improvement of the dairy. He was first employed by the agricultural society as a public teacher in dairy matters, in which position he traveled all over the country, studied the various methods in use, both at home and abroad, and devised many and important improvements. In 1874 he was transferred to the agricultural school at Copenhagen as professor of Dairy Science, which important post he still fills. He had at first to encounter many difficulties in introducing the improvements he proposed. The knowledge of dairying, when he began work, was entirely empirical. The milk was kept cool because it was found by practice that it would thus remain sweet longer. The temperature of the cream in the churn was determined by feeling it with the finger, and salt was added to the butter not by weight but by guess. Prof. Segelcke began at once to alter these empirical methods by pointing out the reasons for the practices followed, and explaining how better results might be reached by following more exact methods. Having received a scientific training as chemist, he soon discovered that exact methods were necessary to produce uniform and satisfactory results.

He thus introduced the practice of weighing the milk that was delivered to the dairy, weighing the cream that was churned, and using the thermometer instead of trial by finger; and he particularly called attention to the advantage of keeping accounts with the cows, crediting them with the amount of milk furnished and charging them with the amount of feed and labor necessary to its production. He soon devised several forms of account which he published and which gradually came into general use, at least in the larger dairies. In traveling from place to place in the pursuit of this work he came into personal contact with all the leading farmers of the country, to whom he pointed out the methods by which they could improve their system, and he thus exercised a paramount influence on the development of the industry. Since his connection with the agricultural school he has, of course, been more confined and less able to take an active leadership in the practical dairy, but his influence has nevertheless been felt through upwards of a thousand pupils who have taken instruction under him at this school.

The system of straining the milk into shallow wooden tubs (Fig. 2), which originated in Holstein and gradually became adopted all over the country, after a time gave way to better methods, although on the

smaller farms this plan is yet followed to some extent. These tubs are about 2 feet in diameter and $\frac{1}{4}$ or $\frac{1}{2}$ inches deep. They were sometimes painted both inside and out, and usually held together by two iron hoops. They were, in some instances, replaced by glass vessels which had obvious advantages in point of cleanliness, but they were too easily broken and it was therefore too costly to maintain the



FIG. 2.—Shallow milk tub.

necessary number in the dairy. Next, large shallow iron pans were introduced as vessels in which to set the milk. These pans were 6 to 8 feet long, from 2 to 3 feet wide, and about 4 inches deep. Fig. 3 gives a good illustration of these pans as they appear when in use. One end was made flaring, so that by tipping the pan the milk could easily run out, and they were frequently balanced on pivots in the center so that they could be easily tilted. This system of shallow setting was supposed to facilitate the rising of the cream



FIG. 3.—Setting milk in shallow iron pans.

since the fat globules thus had but a short distance to traverse to reach the surface. These pans were skimmed by drawing the edge of a board slowly from one end to the other, thus pushing the layer of cream before it. This system is yet occasionally met with, although it is considered antiquated and unsuited to the most economical production of butter.

The next step in advance was the introduction of water in which to cool the milk. This, however, was not always practicable, as cold water of the necessary low temperature was, in places, difficult to obtain; but, the dairyman being convinced that a low temperature was essential to the best results, the plan of using ice instead of water was an easy step to take. Setting in ice water became common. For this purpose cement basins were built in the old milk cellars, and the milk was set in deep cylindrical cans which were sunk into the basins. This is still the method followed where the separator has not done away entirely with the setting of milk. Instead of cement basins, which were rather costly, ordinary large wooden tubs were often used to hold the ice water, as shown in Fig. 4.

It was in the beginning of the '70's that the idea of the separator began to take hold of inventors; but not until 1878 was the first Danish patent granted for a separator, and in the same year a machine was constructed, and exhibited in Copenhagen, which could discharge both cream and skim milk simultaneously with the introduction of whole milk, in a continuous stream. In 1879 it was improved and given the form which in the main it still has, and two years later, in 1881, the patent was bought by a firm who still manufacture it in yearly increasing quantities. The construction of separators had occupied other inventors. In Germany a firm had constructed a machine as early as 1877, but it could not run continuously nor could it remove the cream itself. It was necessary to stop and skim it and refill it with fresh milk.



FIG. 4.—Setting milk in ice water.

In 1879 another German firm constructed a machine which retained the cream and let the skim milk run out, and it was thus necessary to stop and empty it every time a given quantity of cream had accumulated. In the same year, 1879, the Swedish scientist, De Laval, perfected his first well-known separator, which was at once put in use in some of the leading Swedish dairies. Separators are now in general use all over the country. The "butter extractor" which, at one time, promised to revolutionize dairying, has never gained any foothold in Denmark.

DANISH DAIRY CATTLE.

There are, in Denmark, two distinct breeds of cattle besides a large number of nondescript animals which can not be referred to any breed. One of these breeds is found chiefly on the islands, and is known as the "Red Danish Cattle," the other is in the peninsula and is called the "Jutland Breed." Both breeds, or races, have been much improved during the last twenty or twenty-five years, but neither of them has, as yet, reached the highest limit of perfection.

THE RED DAIRY BREED.

The origin of this breed is not readily traced, but it doubtless takes its origin from a blending of the Angler breed of the Duchy of Holstein, which has been imported quite largely into the country, with the native cattle. There are other foreign races which, possibly, contribute, though in a slight degree, to the make-up of this breed. Thus,



FIG. 5.—Cow of the red Danish dairy breed.

Shorthorns have been imported from England, Ayrshires from Scotland, and some few animals have been brought from Switzerland. But the Angler breed has been the most important, and the present red breed also closely resembles the Angler cattle. As the name indicates, they are of a red color, the head is of medium size, horns small



FIG. 6.—Bull of the red Danish breed.

and curved inward, seldom symmetrical, neck light and short, rather depressed, shoulders fine, chest light, chine prominent, hips broad, bag large, milk veins very prominent, legs short and stout, weight about 1,000 to 1,100 pounds. The whole make-up of the cow is that of the ideal dairy animal. She is gentle and easily handled. Figs. 5 and 6 show, respectively, a cow and a bull which are representative animals

of this breed. It is only during the last forty years that the farmers have awakened to the necessity of improving their dairy cattle. Previous to that time the dairy, as we have seen, was a subordinate branch of the agriculture of the country. At that time the farmers thought more of developing a beef breed than of rearing a race which should be superior at the pail; nor has the development been simultaneous in all parts of the islands. The start in improving cattle for the dairy was made by a few far-seeing men, and as their aims and objects became known, others have followed their example; but, even to-day, by no means all of the cattle on the islands can be dignified by a classification in this breed. Owing, moreover, to the division of the country into islands, which of necessity puts a barrier to the free intermixture of the cattle, we may find different types of the breed on the different islands. The Island of Funen contains the best specimens of the breed, and several herds which I there visited are unquestionably of high merit.

There are many examples of the gradual development of the milking qualities of the cattle simultaneously with the fixing of breed characteristics. Mr. Goldschmidt, in his treatise on The Development of the Cattle Interest in Denmark, has compiled statistics from several farms, which shows this development even in a brief period of time. Thus, in 1868, the average yield of butter per cow, on twenty-six farms, was 112.7 Danish pounds. In 1869 the average produce from these farms was 132.5 pounds, per cow. In 1871 the average yield from forty farms was 140.1 pounds, and in 1872 it was 146.4 pounds. Many other similar instances could readily be produced. The following table of milk yields in pounds avoirdupois from several farms and a large number of cows will, in a like manner, show a gradual increase in production:

Average yearly milk yield per cow in the herds of five farms named.

Year.	Sallerupgaard.		Rosenfeldt.		Oregaard.		Marienborg.		Egelykke.	
	No. of cows.	Average milk yield.	No. of cows.	Average milk yield.	No. of cows.	Average milk yield.	No. of cows.	Average milk yield.	No. of cows.	Average milk yield.
		<i>Pounds.</i>		<i>Pounds.</i>		<i>Pounds.</i>		<i>Pounds.</i>		<i>Pounds.</i>
1869.....	71	3,748	.....	.....	112	4,488	186	4,400	84	4,879
1870.....	70	4,167	166	4,523	114	4,400	200	4,380	95	4,472
1871.....	70	4,807	165	4,851	110	4,371	200	4,908	96	4,864
1872.....	67	4,887	167	4,639	115	4,409	220	4,192	96	4,785
1873.....	68	4,906	171	4,785	116	4,455	221	5,130	98	5,024
1874.....	66	4,561	170	4,589	116	4,532	226	5,187	108	4,626
1875.....	66	5,074	170	4,589	118	4,537	227	5,344	108	4,830
1876.....	66	5,489	170	4,449	121	4,466	234	5,193	111	5,121
1877.....	66	5,489	170	4,309	121	4,730	230	5,236	112	5,100
1878.....	66	4,922	205	4,404	125	4,834	231	4,937	114	4,473
1879.....	72	4,673	202	5,232	120	4,969	231	4,904	100	5,530
1880.....	72	4,141	206	4,698	132	4,535	225	4,991	109	4,684
1881.....	67	4,015	206	4,656	128	4,565	224	5,128	115	4,836
1882.....	61	4,988	202	5,542	125	4,679	232	5,042	107	4,892
1883.....	64	5,483	197	5,316	120	4,653	245	5,360	109	5,187
1884.....	60	4,947	200	5,459	122	5,205	249	5,336	114	5,434
1885.....	62	5,402	.....	.....	120	4,856	247	5,208	112	5,259

These yields are from common cattle of all ages and conditions. The table represents about the average of the Danish unimproved dairy

cattle as we find them to-day on the ordinary farms. The improved red cattle are decidedly better, as shown in the following: On the farm named "Naesbyholm," on which in 1882 there were 89 cows, one milked between 11,000 and 12,000 pounds yearly, one between 10,000 and 11,000 pounds, two between 8,800 and 9,000 pounds, sixteen reached 8,000 pounds, sixteen between 6,600 and 7,000 pounds, thirty between 5,500 and 6,000 pounds, and eighteen between 4,400 and 5,000 pounds avoirdupois. A farm on the island of Funen, which has for many years been noted for its excellent specimens of the red Danish dairy cattle, has given the following average per cow of five years old or more:

	Pounds per head.
In 1877	6,611
In 1878	6,970
In 1879	6,969
In 1880	7,933
In 1881	7,147
In 1882	7,365
In 1883	6,913
In 1884	8,292
In 1885	8,416

I have given the yields in avoirdupois. Some few individual cows of the breed will exceed these figures and rise to upwards of 13,000 pounds per year, but it would scarcely be fair to judge the breed as a whole by a few of the choicest specimens. Good average cows of the breed, with good care, may be expected to yield from 8,000 to 9,000 pounds avoirdupois yearly.

THE JUTLAND BREED.

The characteristic cattle in the peninsula of Jutland, which go by the above name, are black and white in color and the dairy qualities are not quite so well developed as those of the red cattle of the islands. They have been handled more as a beef breed, and, until comparatively recently, the fattening of steers was considered of more importance and more remunerative than the dairy business. The cattle had, therefore, for a long series of years been developed for beef rather than for milk. This is, however, now changed, and dairying is there, as elsewhere, the leading branch of farming. The origin of this race is unknown, as this class of cattle has been there from time immemorial. It may be said to be native to the soil and it has been only slightly modified by the introduction of foreign breeds. The color is not altogether uniform, but a large majority of them are black and white, much resembling the Holstein-Friesian breed. The head is usually black and the legs and tail white. In shape they are somewhat heavier in front than the red cattle, the dairy type being not quite so fully developed as in the latter, and the steers fatten readily and attain a good weight. The cows are a little smaller than those of the red cattle, especially in those regions where the soil is poor and the feed not abundant. They are distin-

guished for hardiness and thrive well on moderate feed. The milk yield is also somewhat less than that given for the red cattle. On many farms the average yield of all ages will not much exceed 3,500 pounds per year and on other farms the average reaches 4,500 pounds. This is for common, unimproved stock. In some exceptional cases, where special attention has been given to the selection of the herd, the average will go as high as 6,500 pounds, for cows in good condition. One of the best cows of the breed, which is shown in the accompanying illustration (Fig. 7) has, in the years 1886-'89 inclusive, given respectively 9,273 pounds, 10,488, 10,719, and 9,905 pounds *avoirdupois*; but this is an exceptional animal. On the farm where she belongs the average for the same years was 6,176, 6,799, 7,317, and 7,334 pounds per cow. One of the best herds of this breed is found on the farm named Borupgaard, in central Jutland. This herd has been so improved during the last twenty years that it is now one of the leading herds of that breed in



FIG. 7.—Cow of the Jutland breed.

the country. The improvement has been made by selecting the best cattle which could be found, regardless of cost, and breeding from these only. The milk yields of this herd, from 1880 to 1890, were as follows:

Year.	Number of cows.	Average yield.	Number of cows yielding over 6,000 pounds.
		<i>Pounds.</i>	
1880...	124	5,995	36
1881...	127	5,830	31
1882...	124	5,720	32
1883...	122	5,912	34
1884...	127	5,830	30
1885...	140	5,720	32
1886...	145	5,610	29
1887...	142	5,610	38
1888...	145	6,116	52
1889...	138	5,610	35
1890...	142	6,380	43

This average includes from 15 to 25 cows each year which were not at their best either by reason of having lost their calves or by reason of being barren.

COMPOSITION OF DANISH MILK.

In regard to the quality of the milk of the two breeds, the experiments of Prof. Fjord, in which the two breeds were kept on the same farm and treated in the same manner, indicated that if the Jutland breed gave somewhat less milk than the red breed, the per cent of fat was also a trifle higher, so that for the production of butter there was practically no difference between them, so far as this one experiment would indicate. The average composition of 43 samples of Danish milk, according to Prof. V. Storch, is as follows:

	Per cent.
Water.....	87.64
Solids	12.36
Total	100.00
Solids:	
Fat.....	3.46
Albuminoid substances.....	3.72
Milk sugar.....	4.42
Ash.....	0.76

This is, doubtless, a fair average of the composition of Danish milk generally.

IMPROVEMENT OF THE CATTLE.

As has been stated, the best specimens of these respective breeds are in the hands of a few breeders who have labored skillfully and perseveringly during the last two decades in order to improve their herds; but the general desire to improve has now spread all over the country and there is scarcely a farmer, be his farm large or small, who is not striving with might and main to improve his herd. This is shown in many ways. It has given rise to numerous associations among which, perhaps, the so-called "Bull associations" are the most important.

Bull associations.—These associations are made up of the farmers in a given neighborhood who unite and purchase a superior bull which they use in their respective herds. The purchase price is borne by the association and his keep is paid for out of the service fees. In many instances these associations are aided by small gifts from local farmers' clubs and from a state fund set apart for that purpose. I give an example which will suffice to illustrate all cases, and this is one of several which fell under my own observation. Such an association bull was stationed on a farm in the town of Ringe on the island of Funen. The association that owned him consisted of twenty-nine members, all farmers in the neighborhood. They had selected one hundred of their best cows and he was put to none but those chosen; inferior cows were not eligible. He was a good-sized, handsome animal of the red breed and weighed about 1,900 pounds avoirdupois. He cost about \$162. The service fee paid by members was about 70 cents, but this fee fluctuates with the cost of his keep, as the members are charged only the actual cost. He was

recorded in the herdbook for that breed, was 5 years old and had taken several prizes. The keep of this bull amounted last year to about \$68, which sum was paid to the farmer who had him in charge, and one-third of this was covered by state aid.

Fairs.—The numerous district, county, and association fairs at which animals are exhibited and compete with each other for prizes have a wholesome influence on the improvement of the dairy cattle. Here the best types are shown, their good qualities are made prominent by the prizes they win, and purchases and transfers commonly also take place at these fairs. These institutions are helped, or maintained, under the auspices of the Royal Agricultural Society, which I shall have occasion to mention later. The fairs are a potent force in the improvement of the Danish dairy cattle.

Official advisers.—Another important aid, especially for the inexperienced breeders, is a class of officials who have become quite numerous. They are called "Konsulenter," from the word to consult, which, in a free translation, may be rendered "advisers." The state maintains three such officials in cattle-breeding, and three more for horses and sheep, each of whom is assigned to a given district. Many of the leading local societies have, in like manner, "Konsulenter" or "advisers" of their own. Altogether there are between twenty and thirty "advisers" of the latter class in the country at present. Their business is to answer questions and give advice on all knotty points which the farmer himself does not feel competent to decide upon. They are supposed to be expert in all questions pertaining to cattle-breeding. They are familiar with the history and breeding of all the herds and even individual animals in their respective districts, and, not infrequently, they are also veterinarians. It will be readily seen how they can render important service to the plain farmer in, for instance, the selection of a breeding bull, or in almost any proposed line of improvement. In addition to this they lecture at the gatherings of farmers in their respective districts, thus serving as public teachers, and in a hundred ways are of assistance in the improvement of the dairy stock. Under such methods it is apparent that rapid strides are being made in the development, not only of the dairy breeds, but of the dairy industry as a whole.

DAIRY IMPLEMENTS AND MACHINERY.

SEPARATORS.

First among the long list of machinery and utensils used in the Danish dairy should be placed the separator. There are several patterns in use, but the one most commonly used is the machine shown in the accompanying illustration (Fig. 8). It is there known as the Burmeister & Waine separator, after the manufacturers. The machine, which was invented by a Dane, P. Nielsen, was first used successfully

in Copenhagen in 1878. It has since been improved and altered in many ways, but retains the essential original features. It can raise the skim milk and cream through its discharge pipes to a height of 8 feet, thereby enabling them to run off to other parts of the creamery where the reservoirs may be located. It is the only separator which can do this. Fig. 9 *c* shows this arrangement. It is manufactured in several sizes. The larger forms revolve with a speed of 2,800 revolutions a minute and the smaller form, which is designated as "*B*" by the manufacturers, revolves with a speed of 4,000 revolutions per minute.

Another separator, which I believe to be gaining favor in Denmark, is the so-called "*Alpha*" separator, invented by De Laval. I saw it in use in several places, and the superintendents invariably spoke highly of it. This form is peculiar in that it has a series of inverted tin pans in the drum, between which the milk must pass and which, it is claimed, facilitate the more complete separation of the cream. It is claimed that it can skim 1,750 pounds avoirdupois per hour, at a rate of speed



FIG. 8.—The Burmeister & Wain separator.

of 5,600 revolutions per minute, with the milk at a temperature of 75° to 80° F. The still larger form known as "*Alpha 2*" can skim, it is claimed, 3,500 pounds per hour at a speed of 5,600 revolutions per minute.

A third separator, which is used to a considerable extent, is also of Danish origin. It was invented and first brought into use in 1885 by M. Peterson and J. Nielson. They sold it, however, soon after to the present manufacturers, Koefoed & Hauberg, by whose name it is known. It is claimed for it that it skims the milk clean and works with comparatively light power. There are still one or two others in use of German origin, but only the three here named can be said to play any important part in the dairy business, and in point of numbers in use of each kind they rank about in the order here given. Each of these patterns can also be had in smaller machines for hand power, and these "*Baby*" separators are coming more and more into use in the smaller dairies.

Burmeister & Waine's hand separator is manufactured in two sizes, costing, respectively, about \$68 and \$95, and with respective capacities of 250 and 350 pounds of milk per hour. The Koefoed & Hauberg hand separator is also manufactured in two sizes, costing, respectively, about \$154 and \$117 and with respective capacities of 500 pounds and 400 pounds of milk per hour.

De Laval's hand separators are likewise in two forms, the "Baby" costing about \$62, with a capacity of 120 pounds per hour, and the "Alpha



FIG. 9.—Machinery connected with the separator.

baby" which skims 250 pounds per hour. I did not learn the price at which it was sold.

We will next notice a few pieces of machinery directly connected with the separator. The receiving basin, into which the milk is poured after it has been received at the creamery and weighed, is sometimes a large wooden vessel, either square or circular in form, and in other places it is made of heavy tin. It is always placed on a platform so high above the floor where the separators stand that the milk can run by gravity into

them. It is a well-known fact that the milk is skimmed cleanest when warmed to a temperature upwards of 75°F . The milk does not have this temperature when received from the dairy, nor can it be attained unless it is heated, and for this purpose a piece of machinery has been invented, through which the milk runs in a continuous stream on its way to the separator, and in passing is heated by steam to the required temperature. This machine is known as the "forewarmer" (see Fig. 9 a). It is a simple cylindrical barrel, made of tin or copper, which is "jacketed;" that is, placed inside another and a little larger vessel, so that a space is left between the two, and this space is made steam-tight. The steam is introduced into this space, and it thus warms



FIG. 10.—The Lawrence cooler.

the milk contained in the inner vessel. To warm it evenly an agitator is introduced, which revolves slowly, so as to bring all the milk into equal contact with the heated sides of the vessel. The milk enters the forewarmer at the bottom and runs out at the top. An opening in the discharge pipe permits of inserting the bulb of a thermometer so that the temperature can always be noted.

There are several devices which regulate the inflow of milk into the separator, or other vessels, so that the stream is constant from beginning to end, although there may be a variation in pressure. One of these is known as "Prof. Fjord's regulating funnel," having been invented by him. Another arrangement is to put a "swimmer" in the funnel. A "swimmer" is a cylinder with conical ends, into each of which is put a piece of wire, which thus forms the axis of the cylinder. One end, with its wire, projects into the discharge pipe of the funnel, and the other end, with its wire, projects into the discharge cock of the basin, or reservoir. Now, if the milk runs too fast, this "swimmer" rises up against

the end of the discharge cock, partially closing it and thus regulating the flow. The "swimmer" is used in the funnels shown at *gg*, Fig. 9, and "Fjord's regulating funnel" at *h*. The cream from the separator is run into the suspended vessel *d*, from which it runs through the sterilizer *e* to the cooler *f*. The cream may run from the separator either directly to a cooling apparatus, or, as noted above, through a sterilizer to the cooler. We will note the latter first.

COOLERS.

Three forms of coolers were noticed, and all three cool the milk or cream upon the same principle. A stream of cold water enters the apparatus from below and running through a "worm," or a piece of thin zigzag pipe to the top of the apparatus, it is discharged, the end of the pipe being directed downwards and discharging the water below. The milk or cream is poured into a hopper on top of the apparatus and runs slowly in a thin sheet down over the corrugated sides,



FIG. 11.—The Smith cooler.

and coming thus into direct contact with the cool metal it is cooled to within 4 or 5 degrees of the temperature of the water used. The water may be supplied from a tank or large barrel placed so high that it will run through the cooler. Fig. 10 is a good illustration of the "Lawrence cooler," which I described in my preliminary report. The barrel should be filled with broken ice and a jet of water turned on to keep up the supply. From the barrel it runs into the bottom of the cooler, and following the zigzag pipe it runs out at the top and is discharged through a piece of hose. The substance to be cooled is poured into the small reservoir, whence it flows into the hopper, and then flows over the cooler. The Smith cooler (Fig. 11) is cylindrical in shape instead of flat. The water enters through the hose *e* and is discharged at *f*.

In some cases I found that the water running from the cooler was again raised to the reservoir by a pump worked by the engine that supplied the power for the establishment. This effected a saving of ice, and the water was cooler than it could be if drawn from some outside source. These coolers are made in many sizes. The largest is 3 feet, high in the body, and is claimed to cool 5,000 pounds of milk per hour, from 180° F. to about 3° F. above the temperature of the water used.

PROF. FJORD'S CONTROL APPARATUS.

This invention, which is illustrated in Fig. 12, is in universal use all over the country. It has, by successive steps, been improved and enlarged until it now has the form herewith represented. The Danes think a great deal of this piece of testing machinery, and are firm in the belief that there is nothing equal to it. The inventor is the highest authority in dairy matters that they recognize, and it is impossible that a thing he recommends could be inferior to anything else. I told them of our Babcock milk tester, but my representations met with no favor. The fact that chemicals were to be used in the Babcock test,



FIG. 12.—Prof. Fjord's control apparatus.

was considered an insuperable obstacle which might work dire disaster in the hands of common dairymen who have had no training in chemistry. Fjord's milk tester presented no such difficulty, and to them represented the acme of simplicity and accuracy. As shown in the illustration, it is a nest of glass tubes built up of twenty-four little frames which are suspended from as many arms radiating from a central hub. Each of the small frames holds eight tubes, the whole containing one hundred and ninety-two tubes, and being capable of making 192 tests at once. A small frame is shown both inside view and end view in the illustration. The tubes are about 6 inches long, and half an inch in diameter. It is essential that they should be of the same diameter throughout. In shape they are like the ordinary test tubes, except that the mouth is straight, not flaring. There are no scales or marks on these tubes, but the places they occupy in the frame are numbered from one to eight, and the frames are numbered from one to twenty-four. It will thus be seen that in testing a sample of milk it is only necessary to keep a

record of the place it occupies in the nest. To fill the tubes they use a little dipper, represented in Fig. 13, made of tin. It has a little projecting arm on one side which is put into the tube after it is filled, and thus forces out a quantity of milk equal to the space it occupies. By this means it is possible to get exactly the same amount of milk in each tube. The test is on the centrifugal principle.

The Burmeister & Waine separator has a very large bowl and it is made to attach to an axis which stands perpendicular in the center of the bowl. The hub of the nest is put over this axis and when the bowl is set in motion the nest of samples turns with it, the frames being swung out so that the tubes occupy a horizontal position with the opening pointing inward. The cream in each sample is forced to the mouth of the tube, and by continuing to run the machine for forty-five minutes, which is the usual time, the cream forms a perfectly solid mass which fits like a cork over the milk. Now, by means of the little scales shown in the lower right-hand corner of the illustration (Fig. 12), this layer of cream is measured and recorded for each sample. Then, by reference to a table, constructed by Prof. Fjord to be used in this connection, the operator reads off the per cent of fat contained in each sample of milk. I was told by more than one chemist, who had compared the results of this milk-tester with chemical analysis of the milk, that when carefully handled it would work with perfect accuracy. It is not likely to meet with favor in this country; but I describe it because of the importance it has in Danish creameries.



FIG. 13.
Dipper.

CREAM BARRELS.

The vessels in which the cream is set to ferment may next be mentioned. These were, in nearly every case that came under my observation, simple wooden barrels, although I learned that in some places were used large tin cans of a size suited to the size of the dairy. Sometimes only one or two were needed, while at other places I saw three or more in use. They were made of oak wood and each was supplied with a lid. A double cream barrel I learned was in use in some creameries. It consisted of a tin can fitted inside a wooden tub or barrel. The object aimed at was to maintain a uniform temperature in the cream by guarding against the effect of external fluctuations.

THE PASTEURIZING APPARATUS.

I described briefly this piece of dairying machinery in my preliminary report, and here present an illustration with a more detailed description (see Fig. 14). The form used in Denmark was invented by Prof. Fjord. He introduced an agitator to prevent the burning of the milk or cream. It is made of a copper cylinder covered with tin (Fig. 14aa).

This is fitted steam-tight into a vessel of somewhat larger diameter, *bb*, made either of copper or galvanized iron, and then covered on the outside with wood to retard cooling. The steam is introduced through the opening at *g* into the space between the two vessels and passes out through the pipe *dd*. The milk or cream enters through the pipe *c* into the bottom of the apparatus and it is discharged through the pipe *e*, which has a pocket on the upper side into which a thermometer can be inserted, thus enabling the operator to control the temperature, which he does by letting in more or less steam. The agitator *f* is a simple frame of wood or metal. It is turned at a speed of about 150 revolutions per minute by a belt connected with the shafting. This apparatus is in common use in Danish dairies. It is intended to kill



FIG. 14. — Pasteurizing apparatus.

the microbes, or at least the greater part of them, and thus prevent or retard their propagation, and it is used for sweet milk, for cream, or for skim milk, as the case may be. In some instances the sweet milk is sterilized instead of being merely warmed by the "forewarmer" before it runs into the separator. In other dairies I found that the cream was sterilized and again cooled at once before it was set into the cream barrels to await fermentation. And in nearly all cases where the sweet milk was not sterilized before it was separated I found that the skim milk was sterilized as it left the separator. This was especially the case in co-operative dairies, where nearly all the skim milk was taken back to the producers. Thus treated it would keep better, and in feeding it to calves it was claimed that all danger of possible infection with tuberculosis was avoided.

The temperature to which the milk or cream was heated I found to vary somewhat, but it was usually somewhere between 160° and 180° F. It should be noted that in order to maintain this temperature constantly the steam should be admitted directly from the boiler. Waste steam, it has been found, does not answer the purpose. It may be noted in this connection that when the sweet milk is sterilized by being heated, say to 170° F., the separator can skim it much cleaner than when it runs through at a lower temperature; but, on the other hand, sterilization of either sweet milk or cream slightly diminishes the amount of butter. It increases the amount of butter fat retained in the buttermilk and it diminishes the amount of water in the butter.

THE CHURN.

The next important piece of dairy apparatus is the churn. Of this I found but one pattern and, I believe, only one size. Where one churn was not sufficient to do the work, several were used. The pattern used is represented in the accompanying illustration (Fig. 15). It is a large truncated barrel made of oak wood and suspended, as shown in the illustration, by pivots near the center of gravity, resting in upright posts. This arrangement facilitates the removal of butter and buttermilk and the cleaning of the churn, in that it can readily be tilted to any angle. The cream is churned by a revolving agitator made of wood, shown in the lower left-hand corner of the cut. Sometimes cleats are nailed on the inside of the churn to the number of three or four, which, by break-



FIG. 15.—Danish churns.

ing the rotary motion of the cream, assist in the agitation. In the majority of instances the power used is steam, but I saw also the churn worked by a horse, through the medium of a sweep. The illustration shows the butter-maker in the act of removing the butter with a sieve which drains off the buttermilk.

BUTTER-WORKERS.

The butter-workers used are of the same patterns which we find in this country; in fact, I believe they are of American origin. In former times, before the introduction of mechanical butter-workers, the butter was worked by hand altogether, in a trough, as shown in Fig. 16. It is simply a log of hard wood, usually beech wood, which is scooped out and made smooth. It is so placed that it inclines very slightly to one

end, and thus the buttermilk as it is pressed out will run into a vessel placed underneath, through a hole in the trough. It is only in a few places, and where the dairying is conducted on a small scale, that the butter is worked by hand. The old-fashioned butter trough will soon be classed among the obsolete articles.



FIG. 16.—Butter trough.

BUTTER-COOLERS.

Butter-coolers are found in every dairy. The cooler is a simple box made either of wood or, in some cases, of zinc, in which the butter is kept to cool after it is removed from the butter-worker, and it remains there until it is time to give it the next working. The box is provided with one or more cleats inside, according to its depth, and slats are laid across the box on these cleats on which the butter is put, as shown in Fig. 17. In the illustration, *a* represents the cleat, *c* the slats, and *S* the butter. The box is covered with a lid on which is put a layer



FIG. 17.—Cooling box for butter.

of broken ice, and the ice water from the melting of this ice runs down into the bottom of the box. To facilitate the cooling, the butter is rolled into an arch, as shown in the illustration. In some of the larger dairies which I visited these boxes admitted of placing two or three layers of butter to cool at once.

DAIRY SCALES.

Every dairy is supplied with several scales of varying sizes. The decimal weight is used everywhere. Instead of moving the weight

along on the lever arm, as we usually do, there are two platforms, one on which to place the object to be weighed and on the other the weights of different sizes. In many dairies they use a weight on the receiving platform for the milk, which has a basin holding from 50 to 75 gallons. The milk is poured into this and when a certain weight is reached it is checked off and the basin is tipped so that it empties its contents into the large milk vat.

BUCKETS AND MILK CANS.

Of these many styles are used. They are generally made of heavy tin and they are not infrequently enormous in size. The cans in which the milk is transported are of two general forms, square and round, and the mouth is so large that it admits a hand and arm readily. Frequently the weight of the can is stamped upon it, or it is stamped upon a brass plate and soldered to the can, thus obviating the weighing of the can.

CHEESE VATS.

These are of two general forms, the oblong box and the cylindrical vat. In the latter the milk is warmed only through the bottom, which is double and made of copper, admitting steam to be injected between it and the real bottom of the vat. The square form is of the type in common use in this country. The cheese presses are also found in several patterns, none of which are superior to those in use in this country. The horizontal press is known as the "American" cheese press, and has been imported from this country.



FIG. 18.—Scrubbing brushes.

CLEANING UTENSILS.

Of these there is a large variety of scrubbers and brushes in use, some of which are represented in Fig. 18. Strainers, thermometers, measuring glasses, etc., are of numerous patterns, but I did not notice any that were improvements on those in use here.

SYSTEMS OF CREAMING.

The system now in use is, as has already been indicated, the separator system, but previous to its introduction there were, as noted under the heading of the development of the dairy, several transitions from one improved method to another, and all of these can yet be seen represented on Danish farms. I will, therefore, briefly describe them, inasmuch as conditions in this country may be such that a farmer now and then can use one or the other of them to advantage.

I.—SETTING MILK IN SHALLOW VESSELS.

It was early recognized that it was necessary to keep the milk in a uniformly cool temperature in order that the cream might rise in a reasonable time and the milk keep sweet, and to produce this condition it became customary to keep the milk in cellars or basements. These were not, as the word might imply, dark places deep in the ground, but they were usually 4 or 5 feet deeper than the surface of the ground, windows and ventilators to supply light and fresh air being put in; and to-day, with the improved separator system, we find these basements still in use, not because they are a recognized necessity, but because they remain in the buildings as remnants of a former system. In the new creameries, which are now being constructed, cellars are frequently wanting. The old method of setting the milk in shallow vessels where it stood from twenty-four to forty-eight hours before it was skimmed required an even, cool temperature, and the cellar was, in that day, the nearest approach to that condition. The milk was strained into shallow wooden tubs and these placed by companies and platoons in rows upon the floor, a narrow alley way separating one milking from another.

This system of setting the milk required an unusually large cellar. It required from 12 to 20 square feet of space for each cow in the dairy. This had the advantage that there was always a large volume of air in the room and that by careful ventilation the air could be kept sweet and fresh. It was also necessary that these cellars be thoroughly drained, so that all moisture which collected in the course of cleaning could be easily led off. The floor was usually made of brick set on edge; later on it was occasionally made of cement, and in exceptional cases it was made of hewn stone. The vessel most commonly in use, in which the milk was set, is shown in Fig. 2. The cream was skimmed off when it had stood, as stated, from twenty-four to forty-eight hours. In summer the skimming usually took place in twenty-four hours and in winter in thirty-six to forty-eight hours. This shallow tub was made of oak wood 2 feet in diameter and 5 inches high inside. The quantity of milk set in the tub differed with the different seasons, from 1½ inches to about 3½ inches deep. The chief objection to this system is that too much of the cream remains in the milk. In summer when it is neces-

sary to skim the milk in twenty-four hours, frequently 1 per cent or more of the fat will remain and, of course, become lost to the butter-maker. The cream is skimmed off by means of a large flat spoon made sometimes of wood but usually of tin, circular in shape, some 6 to 10 inches in diameter and but little dished. The dairy maid would, with a dexterous move with this spoon, first loosen the cream from the sides of the tub and then gather it in rapidly in two or three spoonfuls and collect it in the cream bucket which she carried with her. The most difficult part of the management of this system is to know when to skim the milk, and to so ventilate the cellar that the cream and the butter receive no bad taste or smell. To get the best quality of butter the milk is skimmed while it is sweet. What butter fat is left in the milk is not to be considered as a total loss inasmuch as a large part of the skim milk is made into cheese, and what is thus lost in quantity of butter is gained in quality of cheese.

II.—SETTING MILK IN IRON PANS.

The long, shallow, iron pans which I have already mentioned (see Fig. 3), and which are yet seen in many dairies, were brought into use for the first time in 1843 by Hr. V. Destinon in Holstein. They are of several sizes, but perhaps the most common size is 7 feet long by 2 feet broad and 4 inches deep, having at one end a handle by which it can be raised and the other end flaring for the outlet of the milk and cream. Sometimes they are placed upon the edges of a brick basin, which is filled with cold water, the water, if possible, being made to circulate or run through the basin and reach to near the edge of the pan. The water is supposed to aid the cream in rising more rapidly and also in keeping the milk at a uniform temperature, but it has this disadvantage, that it keeps the air in the milk room very moist and more difficult to hold sweet and fresh, and in summer, when fresh air is most needed, it favors the formation of molds, which is decidedly undesirable. For these reasons water is not often introduced, nowadays, and instead of the basins the pans are most frequently placed on low stools or blocks of wood. These pans are somewhat easier to handle than the wooden tubs which, in a large dairy, are very numerous and of necessity have to be carried about from the milk cellar to the wash room, where they are boiled out and then cleaned in cold water; they are next placed in pyramids on racks out of doors to air and dry. The iron pans can be scrubbed down in scalding water without being required to be aerated and sun-dried in order to keep them sweet.

On the smaller farms, where the dairy consists of only a few cows, the milk has very generally been set either in earthenware dishes or in enameled iron pans. These are still in common use on small farms, and they are placed either on the floor or on shelves in the milk room. The chief objection to all of these forms of setting the milk lies usually in

the premises. If it is possible to have a dry cellar on the north side of the house, so situated that no bad odors from outside can get into it with any direction of the wind and which permits free ventilation, this system of setting milk, especially when the skim milk is used for cheese, is not a bad one. But in too many cases it is difficult to meet these necessary conditions, and whenever the cellar is objectionable it is impossible to make a first-class article of butter.

III.—SETTING MILK IN COLD WATER.

This system, which was used in some dairies for a number of years, was borrowed from America, and it was even sometimes called the "Orange County System," after Orange County, N. Y., where it was common. The plan consisted, as in this country, of setting the milk in deep cans in cold water—spring water, if it could be obtained; well water raised by a pump, if nothing better could be had. However, it never came into general use, although the results were, on the whole, satisfactory where the water supply was sufficient. Some of the leading farmers adopted the plan, but after some years it was modified by the use of ice.

IV.—SETTING MILK IN ICE WATER.

The use of ice was the outgrowth of the cold-water method. A few trials proved conclusively the great advantage of cooling the milk rapidly and maintaining it at the lowest possible temperature by the use of ice. But the great difficulty was to preserve a sufficient quantity of ice for this use in a large dairy. This question led to Prof. Fjord's experiments in the construction of ice houses, which I shall mention later on. Early in the '70's the practice of using ice to cool the milk became general wherever it was practicable to obtain and store the ice. The method was to use the old water basins constructed some eight or ten years before, when the water system came into repute. The conditions were favorable to the use of ice; that is, the aim had been all along in the construction of milk cellars to reduce the temperature to the minimum in warm weather, so that the ice lasted longer than it would have done had the milk room been entirely above ground and no provision made for the use of cold water. On the smaller farms the ice basin frequently consisted of large wooden tubs of the proper depth, into which the cans were sunk (see Fig. 4). I found this method in use yet on many of the smaller places where the milk was not sold soon after milking to some neighboring creamery, or where the separator had not been introduced. Prof. Fjord, who has done so much for the development of the Danish dairy, experimented largely in order to ascertain the relative values of setting milk in cold water and in ice water. By cold water we are to understand such water as can be obtained from springs and wells, usually in that country ranging in

temperature between 50° and 60° Fahrenheit. He proved conclusively that the milk ought to be cooled as soon as possible to a temperature as near freezing as could be obtained, by the use of ice water in summer; and he proved further that the depth of the milk in the can had but little influence on the rapidity of the rising of the cream, provided it was kept at a low temperature.

The following table, by Prof. Fjord, shows the advantage of rapid cooling to a low temperature compared with the use of cold, still water:

	Cream from milk skimmed after standing ten hours.			Cream from milk skimmed after standing thirty-four hours.		
	In ice cooled at 35° to 36° F.	In still water at—		In ice cooled at 35° to 36° F.	In still water at—	
		39° to 40° F.	50° F.		39° to 40° F.	50° F.
Average of experiment.....	Per cent. 100	Per cent. 96.4	Per cent. 74.9	Per cent. 100	Per cent. 98.6	Per cent. 86.6
Per cent of cream lost by use of water without ice.....		3.6	25.1		1.4	13.4

From this it will be seen that a great loss is sustained by setting the milk even at so low a temperature as 50°, compared with a temperature but little above freezing. The next table shows the loss in per cent of butter, which is sustained by skimming the milk after standing ten hours, compared with thirty-four hours' standing, both by the use of ice and the use of water at different temperatures.

	Per cent of butter by standing.		Loss of butter in per cent by standing.	
	Thirty-four hours.	Ten hours.	Thirty-four hours.	Ten hours.
Perfect cooling in ice.....	100	94.3	0.	5.7
Imperfect cooling in ice.....		90.3		9.7
Cooling in water at—				
39.2° F.....		98.6	1.4	9.1
42.8° F.....		96.8	3.2	
46.4° F.....		91.9	8.1	19.3
50° F.....		87.0	13.0	29.4
51.8° F.....		85.5	14.5	29.9
53.6° F.....		83.6	16.4	

These results were obtained by Prof. Fjord in his experiments on the subject. The table is copied from "Mælkeribruget i Danmark," by B. Bógild.

Prof. Fjord also constructed tables showing the amount of ice required to cool 100 pounds of milk under different conditions, during the several months of the year. The experiment, however, was based upon the average temperature of each month in Denmark. As the conditions in America vary greatly in different places, all of which will have a higher average temperature in summer than there is in Denmark, these tables will not have much practical value for us. By the use of good ice houses and by careful, economical use of the ice, the safest guide to follow will be to put up as much ice as the weight of the milk which is to be handled throughout the year, pound for pound.

V.—THE SEPARATOR SYSTEM.

As already stated, the separator is now in general use. It will not be necessary to detail the method of operation followed, inasmuch as it is known to every creamery man in this country. I will note only a point or two which are not generally practiced here. I have already called attention to the Burmeister & Waine separator, by means of which the cream and milk can be transported through pipes to their respective reservoirs directly from the separator (see Fig. 9). In the coöperative creameries it is now a common practice to sterilize the skim milk directly after it leaves the separator, and wherever this make of the separator is used the skim milk is carried to the sterilizer, often at an elevation of 6 or more feet above the separator, without the intervention of pump or any other force than that given to it by the drum in the separator. The cream is in like manner carried to the cream barrel, if so desired. This is a saving of labor which is not possible with any other separator. The one objection which I found urged against this method of transmitting milk and cream was that it frothed too much. The skim milk is sterilized at a temperature very near the boiling point when it is not intended to use it for cheese. The object is twofold—first, to increase its keeping qualities so that it can be carried back to the farms without souring, and, second, it is sterilized in order to kill possible germs of contagion, such as tuberculosis. The milk coming in from so many places there is always a strong presumption that some of the cows may be tuberculous, although they may not show it by examination; and the milk being mixed, other dairy farmers with sound cattle object to using the milk in their households and for their calves and pigs unless it is thus sterilized.

TREATMENT OF THE CREAM.

Sweet-cream butter has so far not come into demand in Denmark either for home consumption or for export, and there is but little, if any, of that article made. The treatment of the subject is therefore confined to the methods practiced for the production of butter from sour cream. There are two reasons for souring the cream aside from the one that sweet-cream butter finds no sale: First, it is found that sour cream yields more butter than sweet cream, and, second, souring or fermenting the cream is, in accordance with the present standard, thought to increase the aroma and good taste of the butter. Experiments have proved that the difference in yield of butter by the two systems is about 4 per cent, or very nearly equal to the difference of one pound of milk for each pound of butter.

STERILIZATION OF THE CREAM.

The first essential condition to success in butter-making is to have a good quality of cream. It must not be affected by bad odors, nor by *bitter*, salt, or other offensive taste. These faults may be due to the

cows, in which case their milk should be withdrawn from the creamery. Investigations have proved, however, that in the vast majority of instances faulty cream is due to bacteria, many forms of which, both useful and injurious, have been discovered. To counteract their influence it has been the practice in many Danish dairies, during the last three or four years, either to sterilize the cream immediately after it is separated or the milk before separation takes place. How this could be done was first pointed out by the great Frenchman, Pasteur. He showed that by heating the liquid containing these bacteria up to 75° or 80° C., the greater part of them would be killed, and after him the method is frequently called pasteurization. Prof. Fjord was the inventor of the sterilization apparatus, which has already been described and which is in common use; but it is not absolutely necessary to use this machine. The same result can be reached by the use of boiling water, whether this water is heated by steam or in a kettle over the fire. The latter method I saw used in several places with success. In that case the cream is put into tall cylindrical milk cans, which have first been thoroughly cleaned by washing in mild lye, or by the addition of soda to the wash water, or with water containing lime in solution, and thereafter cleaned by a jet of steam, or, if steam cannot be had, scalding water.

The cream cans are sunk to the rim in the hot water, and this is kept near the boiling point either by the constant addition of boiling water or, what is more convenient, by heating it with a jet of steam through a pipe. The cream in the cans is constantly stirred, so that it may warm equally through the mass, care being taken that the paddle used to stir with has been thoroughly cleaned. It is, in most cases, made of galvanized iron. The dairymaid holds in one hand her thermometer immersed in the cream, while with the other she keeps up the stirring, watching the rise of the temperature all the while, and when it reaches 80° C. (176° F.), which temperature should not be exceeded, she lifts the can out and at once immerses it in ice water, where, by continual stirring again, it is cooled as rapidly as possible till it reaches about 35° or 36° F. It can then remain standing in the ice until such time as it is found convenient to begin the fermentation. The sterilizing apparatus differs from this as to result only in that it does the work more rapidly, with greater certainty, and with less labor on behalf of the dairy people. As already described, the cream runs into the bottom of the apparatus from a reservoir, which may be filled directly from the separator, and after being heated by the steam while it is stirred by the agitator in the machine it runs out again at the top in a continuous stream, and the cream is then either cooled by immediately running over one of the coolers described or it may be placed in cans and these be set in ice water. The object of it all is to free the cream from bacteria of all kinds, and then, by the addition of a previously prepared ferment which is known to be pure, to ferment the cream to such a degree that it shall be capable of producing the best quality of butter.

METHODS OF FERMENTATION.

(1) *Natural souring.*—Treating of these in the progressive order in which they have been brought into use, I shall first mention the souring of the cream without attempting to influence the result by artificial means. This is the old-fashioned way. It is still used now and then on small farms, the owners of which have not kept pace with the times. Sterilizing is unknown to this method. When skimmed from the milk cream is at once poured into the cream barrel, which is kept in some corner of the milk room, or, in the colder seasons of the year, may be alongside the stove in the kitchen, or in any warm room where it will be liable to sour quickly. This method, as stated, is now used only in small places; but I mention it here because with careful manipulation the results may be entirely satisfactory, provided that the milk room is clean and sweet, that the milk is from sound cows, that the stable is kept clean and airy, and that there are no contaminating influences outside, such as from stagnant water or manure heaps and the like, which can gain access to the dairy room through the air. This might be styled self-souring, or natural souring. I would not have it understood that all Danish dairies sterilize their cream or milk, for this is far from being the case; they do so only when they find it necessary in order to produce butter of first quality. I visited several places where the conditions were so favorable, the premises kept so clean, that it was not necessary to sterilize the cream at all, but they, nevertheless, fermented the cream by one of the following methods.

(2) *By the use of buttermilk.*—In this case a portion of the buttermilk is taken from the churn immediately after the butter is removed and added to the cream barrel. The quantity used will differ much according to the quantity of cream, the sourness of the buttermilk, and the season of the year, and also with the length of time that the butter-maker desires to give to the fermentation. It is a matter which each butter-maker decides upon for himself according to his experience. But I can say that it does not usually exceed 10 per cent of the cream nor less than 5 per cent. The objections to the use of buttermilk are, that if there is any defect in the churning from which it is taken it will, of course, transmit the same defect to the cream, and the undesirable qualities are thus perpetuated. It is also somewhat more difficult to keep the fermentation under complete control, in that the buttermilk is liable to vary more in acidity than any other form of ferment. If it is found by experience that the buttermilk does not produce the right flavor in the butter, from whatever cause, it is a common practice to resort to a neighboring dairy for the buttermilk; and experience has proved that sometimes this expedient will entirely overcome the injurious influences which affect the cream and butter, and that when this is done once or twice the buttermilk from the home dairy can again be used for some time with entire satisfaction. Before the ferment, of whatever kind, is added the cream should be raised to a temperature

which varies between 70° and 95° F. This is done either by running it through a forewarmer—the apparatus described as being used to heat the milk before it runs into the separator (see Fig. 9)—or by simply immersing the cans of cream in warm water and gently stirring until it reaches the desired temperature. Still another method of warming it is to insert a cylindrical can of small diameter filled with boiling water into the cream can or cream barrel and allowing this to stand until the cream reaches the desired temperature, it being gently stirred in the meantime. In any case the cream should be warmed to the degree mentioned before the buttermilk or other ferment is added. In the cool season of the year precautions are taken to prevent the falling of the temperature too low in the cream barrel until the fermentation is complete. These precautions consist either in keeping the room warm by a stove or steam pipe or in having the cream barrel stand in a box or large barrel prepared for the purpose, so that it can be packed all around with hay, and a similar covering, either a quilt or hay mattress, is put over the lid of the cream barrel. The proper degree of fermentation is usually reached in the course of eighteen to twenty hours. The butter-maker starts the fermentation at such a time that the cream will be ready to churn at the most convenient hour the following day. I found, in most cases, that the fermentation was started at about noon; the cream would then be ready to churn by 6 o'clock the next morning. During this interval it was gently stirred two or three times and the progress of the fermentation watched by the changes in appearance, in taste, and in smell.

(3) *By the use of sour cream.*—Sour cream is occasionally used as a starter. A portion of the cream churned to-day is thus set aside in the morning, and at noon added to the cream that is to be churned to-morrow. Practical butter-makers admit, however, that sour cream is even less desirable than buttermilk, for the reason that, owing to the presence of the fat and off taste which it might have, it is not so readily detected as in the use of buttermilk, and it, in like manner, perpetuates whatever faults there may be from one churning to the next. In all other respects the preparation of the cream for churning is the same as already described.

(4) *By the use of skim milk.*—In the use of both buttermilk and sour cream as a ferment there is a continual perpetuation of the same fermenting elements from week to week, and month to month, as long as continued. It is found that, in many cases, injurious bacteria creep in, and, after a time, the ferment degenerates and fails to produce the good quality of butter that it did at first. This is, in a measure, obviated by the production of fresh ferment every week or two, as the case may require. Such ferment is usually made from half-skimmed milk, that is, milk which has stood from ten to twelve hours and then been skimmed. It is this milk which, by being heated to about 100° F., and then allowed to stand at a temperature of about 70° F. for from

twenty-four to forty hours, according to the season, will develop the ferment, which can be used for souring the cream. The milk used for this purpose should be from a nearly fresh cow. Milk from cows about to go dry does not answer the purpose. Good judgment is required on the part of the butter-maker to obtain the right degree of acidity in this ferment. He examines it frequently, smells it, tastes it, and notices its consistency. It should have a certain degree of thickness, and show the formation of small granules, and should have a clear, sharp taste. If it has a bad smell or taste, or if it does not thicken properly, it should be rejected. As soon as it reaches the proper degree of consistency and sourness the fermentation is stopped, by immersing the can containing it into cold water, where it can remain for a few hours, if necessary, before it is added to the cream. The cream is prepared to receive this ferment by being warmed to a degree varying with the season, from 75° to 84° F., or even more. The top of the ferment in the can should then be skimmed off and discarded, as it may be contaminated with bacteria from the air, and from 3 to 5 per cent of the volume of the cream is added to the cream barrel from the remainder. The cream barrel is now covered and kept at a temperature of about 75° F. until it is ready to churn on the following day. The length of time that it stands varies with the season and the temperature in the cream room, from eighteen to twenty-four hours. This, however, is not the invariable method followed.

Sometimes cream is added to the skim milk before the fermentation begins; at other times the milk is not skimmed at all. The result, however, is the same. A new ferment is obtained, which, if the proper care has been exercised in its production, is capable of souring the cream in such a manner that it will produce a first quality of butter. However, this expedient does not always work satisfactorily. If the dairy building or the surroundings are impregnated with injurious bacteria these are sure to infest this new ferment also, and it fails in a short time.

(5) *By the use of pure cultures.*—When all things else fail to produce the desired quality of butter, resort is had to the use of an artificial ferment, the so-called “pure cultures.”

The Danish dairy experts have been at work for several years on the isolation and culture of those bacteria which have been found to be the active agents in the fermentation of the cream and, some two or three years ago, success was so far attained that these artificial cultures were offered on the market for use in the creameries; and at the time of my visit last winter there were three laboratories in which these ferments were cultivated and sold. The methods followed in the production of these cultures are secrets belonging to the respective establishments, which will not be divulged. However, it would appear that any good bacteriologist who had studied the question carefully could reach the same result. The bacteria used were obtained from the finest qualities of butter. They have been isolated and experiments have

revealed the nutrients needed for their growth and the temperatures at which they can most readily be propagated. I do not think that any of them claim to know all there is to be known on the subject. They steadily discover that improvements can be made by slight alterations in the methods and that new bacteria heretofore unknown are added to the list. It is certain that the different species of bacteria produce notably different results in the taste and aroma of the cream and butter. Mr. E. A. Quist, of Skanderborg, uses only two species, very distinct in appearance and in the quality they impart to the butter. They are cultivated separately and mixed just before they are sent out to the customers. Blauenfeldt & Tvede, on the other hand, use several kinds in their ferment, which may or may not include those used by Mr. Quist. The results of the use of these pure cultures have been so eminently satisfactory in practice that I found them in very common use. A new starter of these cultures is not needed every day or even every week; and as they are sold reasonably cheap, the expense connected with their use is but slight. When used according to directions sent with them they insure the production of a first quality of butter, which is of greater consideration than the expense their purchase involves. The three laboratories I have mentioned prescribe different methods of procedure in their use, which proves that there is no hard and fast rule that must be followed in order to obtain the desired results. That is, there is a possibility of the extension of this science far beyond our present knowledge of the subject. These artificial cultures are used more particularly in dairies which seem to be infected with injurious bacteria and, to attain the best results, the cream should be sterilized before the ferment is added. The pure culture is added to a small portion of sterilized milk or cream, and then set aside at a given temperature until it has attained the proper growth. It is then further propagated in a still larger quantity of milk or cream and, when a sufficient quantity has been obtained, it is added to the cream in the cream barrel, where it accomplishes the desired fermentation in from eighteen to twenty hours. At the time of my visit none of the laboratories had succeeded in devising means to perpetuate the ferment outside the laboratory for any length of time. It was, therefore, a difficult matter to obtain pure cultures for transmission to America. The preparation required for their transportation during two or three days would not answer the purpose when the journey was extended to as many weeks. I am convinced, however, that it will not be long before this difficulty will be overcome.

There are a few points in the treatment of the cream concerning which no definite directions can be given. One of these is the per cent of ferment, whatever kind is used, which should be added to produce the best results. This depends upon so many things that no definite rule can be given. It depends upon the sourness of the ferment when it is added, upon the length of time it is desired to have the

cream stand before it is churned, and upon the temperature which it is practicable to maintain; and in the adjustment of these to one another the butter-maker must follow his own judgment and experience. It is a well-known fact that the fermentation proceeds more rapidly in warm weather than in cold weather, and in summer the process, therefore, usually takes a shorter time than it does in winter. It is essential that the cream should stand in a room with fresh air. In damp and musty air the cream will be sure to lack the aroma and pleasant taste which are so highly prized. It is a maxim in Danish dairying that to obtain the finest quality of butter, which shall keep well, the fermentation must be strong, and that it should not be stopped until the cream has become thick and shows a peculiar granular appearance and at the same time develops the pleasant aroma belonging to good butter. When this point is reached the cream should be churned.

CHURNING.

I saw but one pattern of the churn, and this has already been described. Years ago, before the dairy had reached its present perfection of methods, the old-fashioned dash churn was common in the small dairies. It then required the united aid of the entire household to keep it going at the requisite speed until butter "came." On the large farms the churn with the revolving dasher has always been the favorite, and is the one still in use. The churn is scalded inside with boiling water and immediately afterwards rinsed in fresh cold water before the cream is poured in. The cream should be of the temperature which experience has proved to be the best for the season of the year. This temperature may vary from 50° to 70° F. Thus, milk from cows that are about to go dry requires to be churned at a higher temperature than that from fresh cows. The usual temperature at which to churn is between 55° and 60° F. The quantity of cream should be known in order that the right quantity of butter color can be added. This quantity differs with the demands of the markets, the quality of the color used, and the feed given the cows; so that no rule whatever can be laid down, and there is no uniformity in the Danish practice in this particular. The English market, where practically all the surplus butter is sent, demands that it shall be of a rather light straw color, and so well do the producers meet this demand, under the varying conditions, that it is only the expert eye that can detect differences in the color of the butter from different parts of the country when collected in the warehouses of the wholesale dealers. I saw this practically illustrated in London.

When all conditions are right the length of time taken in churning varies from thirty to forty minutes, but the time, too, is dependent upon several conditions. It depends upon the speed at which the dasher is revolved, upon the construction of the dasher, and upon the condition

of the cream, both as to consistency and temperature. The kind of feed given the cattle also has an influence upon it. The higher the temperature, the shorter the time required; but all butter-makers with whom I came in contact were agreed that it is better to churn at a too low than at a too high temperature, as the grain of the butter will, in the latter case, be spoiled. There is, however, danger of getting the temperature too low, especially towards fall when the cows begin to go dry and the weather gets cooler. It is then often the case that the cream will froth and the butter refuse to "come." This is obviated by raising the temperature above the normal. In obstinate cases of this kind it is a common practice to stop the churn and let the cream stand until the following day when it is warmed some 5° or 6° higher than usual and again churned, when the difficulty is generally overcome. The temperature of the cream is watched from time to time as the churning proceeds, and for this purpose there is a hole in the lid through which a thermometer can be dipped into the churn. Usually the agitation of the cream causes the temperature to rise some 3° to 5° in the course of thirty minutes. This is as it ought to be, but if the rise is much greater than that it is an indication that the cream was not at the proper temperature when the churn was started. The formation of the first granules of butter is carefully watched for, and for this purpose there is a short piece of wood or stick with a deep furrow on one side put through a hole in the lid, in which it fits closely. This is removed from time to time to see the size of the granules as they collect in the groove. It is of the utmost importance that the churn be stopped at the right time. If continued longer than necessary the grain of the butter is injured. It is the usual practice, when the granules are about as large as small peas, to stop the churn and to add a small quantity of cold water which is thrown upon the lid and down the sides of the churn, after which the dasher is again started at a slow motion until the butter is sufficiently gathered.

TREATMENT OF THE BUTTER.

The first thing the butter-maker does after the churn is stopped is to wash down the sides of the churn with fresh cold water. In some places boiled water which has again been reduced to normal temperature is used for this purpose. This is to avoid contaminating the butter with bacteria which the water may contain. Perfectly pure well or spring water is, however, used without first being boiled. The churn is invariably stopped while the butter is still in small granules or pellets. The butter is next removed from the churn, which is done as follows: The churn is tipped, as shown in Fig. 15, and with a sieve the butter is gathered as it floats in the buttermilk and transferred to a tub by the side, allowing the buttermilk to drain through the sieve as much as it will. Usually a fine hair sieve is used. Finally the

buttermilk is run through a strainer in order to collect the last floating particles of butter. In some places I noticed that it was the practice to dip each sieve full of butter into a tub of clean, cool water, and let this drain through the sieve, thereby washing out a portion of the buttermilk. This, however, is not a common practice. Formerly the butter was sometimes washed in the churn before it was removed, the buttermilk first having been drained off, but this, too, is now obsolete. The Danes believe that butter so washed absorbs too much water, and is less liable to keep.

The next operation consists in pressing the buttermilk out of the butter. In former times this was always done in the butter trough shown in Fig. 16, and by the hands only, or simply by the use of a large wooden paddle made for the purpose. Now, in comparatively few dairies is the butter touched with the hands, and in that case a lump weighing perhaps 8 or 10 pounds is taken up with both hands and put against the sides of the trough, pressed gently with the palms of the hands five or six times, the ends of the flattened mass being turned in after each pressure. In most places the butter-worker is used and is permitted to run under the valve three or four times. When the hands are used, the greatest care is taken that they are clean and cool. They are washed frequently and thoroughly and they are always dipped in cold water before the butter is touched. This is essential, not only to cool the hands, but to prevent the butter from sticking to the fingers, and the same precaution is taken with all the utensils with which the butter comes in contact. Everything is scrubbed first in boiling water to sterilize the implements, and next in clean cool water.

As soon as the buttermilk has been removed the butter is weighed in order to calculate the amount of salt required, and the salt is worked in at this time, always on the butter-worker. Sometimes it is put in at one working, and in other places it is preferred to add it in two workings. The amount of salt used I found was not uniform. It was adapted to the taste of the market where it was expected to be sold, but it varies between 4 and 5 per cent of the weight of the butter. The salt is not weighed, but measured in a large glass with a scale graduated to grams on the side, 5 grams being equal to 1 per cent. Usually the butter is sold, as I shall explain later, to butter dealers, who handle it either on commission or they buy it outright on their own account. These dealers are supposed to know the wants of the market, and it is customary to accept their instructions in regard to the amount of salt and color to be added to the butter. The salt is worked into the butter with the least possible amount of handling, and it is then laid aside for some time before the next working takes place. In summer it is put in the butter-coolers already described (see Fig. 17), which are a sort of ice box. In winter it may simply be laid in large rolls in the butter trough or on a table provided for the purpose. It

reached, the cream can was at once removed and immersed in a basin of ice water, where it was cooled to about 45° F. The dairy was in charge of an able dairywoman, and all the help in the dairy consisted of pupils who worked for their board, and neither gave nor received remuneration. Artificial cream ferment from the laboratory of Blauenfeldt & Tvede was used. The cream was warmed to 70° F. before the addition of the ferment, and at this temperature was set in the cream barrels, where it remained for twenty-eight hours in winter, falling in that time to about 60° F., at which temperature it was churned.

The churn was worked by horse power and the butter came in the same time as in the other dairies I visited where steam power was used. It required, at that time of year, 29 to 30 pounds of milk to produce a pound of butter. The butter was worked three times, in each case by hand; first, for the removal of the buttermilk, immediately after which 5 per cent of salt was added; then it was allowed to harden and the salt to melt for one hour, when it got the second working, the object being, this time, to mix the salt thoroughly; the third working took place two hours after the second.

A fine quality of skim-milk cheese was made at this dairy. The process was, briefly, as follows: The milk was warmed to 95° F. and at this temperature was added 8 per cent of buttermilk and the necessary quantity of rennet, according to its strength. If color was used it was also added then. It then stood untouched for twenty minutes while the rennet did its work. The curd was next cut and then stirred for fifty-five minutes. If the temperature had fallen during that time, it was warmed up to 96° F. by admitting steam under the vat. Half the whey was then drawn off. It was next stirred for fifteen minutes, when the remaining whey was drawn off and the curd was worked by hand. One-fourth of a pound of salt was then added for every 100 pounds of milk. The curd was then put into forms and given half pressure. At the end of an hour it was turned and replaced under the press, and two hours later it was turned again. Full pressure was then applied and it stood undisturbed until evening, when it was turned once more and a fresh cloth wrapped about it and it was again put under the press. Next morning it was taken from the cheese cup and put in strong brine, where it remained for two days; it was then put in the cheese room where a temperature of 52° to 55° F. was maintained, and there all the cheeses were daily turned and rubbed with salt or strong brine once a week. This continued for three months.

The rotation followed on this farm was as follows: First year, fallow; second year, rye; third year, barley; fourth year, one-fourth roots and three-fourths annual grass; fifth year, oats; sixth year, clover; and seventh year, one-half mixed barley and oats, and the other half in grass from the previous year's seeding. On a small portion of the farm a four-years' rotation was followed, being first year, rye; second year, roots; third year, barley; and fourth year, grass. The grass was

sown with the oats and barley, respectively, in rotation. The yield of hay was about two tons to the acre. For the annual grass they used a mixture of oat grass, English rai grass, yellow medick, and sometimes a little bromus arvenses.

For the two years' grass crop in the seven-year rotation they used red clover, orchard grass, English rai grass, and meadow fescue. The average yield of rye was 50 bushels to the acre; of barley, 45 bushels; of oats, 60 bushels to the acre; and the yield of roots went as high as 24 tons to the acre. I append a statement of the receipts from the dairy, which Superintendent Tuxon kindly permitted me to draw from his books.

Statement of the products of Thurebylille Dairy and their values for the years named.

[Year reckoned from May 1 to April 30; weights in pounds avoirdupois.]

	1886-'87.	1887-'88.	1888-'89.	1889-'90.	1890-'91.	1891-'92.
Number of cows giving milk.....	135	129	127	123	127	130
Yield of milk..... pounds avoirdupois..	726,752	771,810	746,447	738,133	766,286	772,275
Average yield of milk per cow.....do....	5,383	5,982	5,877	6,000	6,033	5,940
Average yield of butter per cow.....do....	183.5	207.6	204.4	198.9	196.2	203.2
Butter sold per cow (inclusive of household consumption) pounds avoirdupois..	182.1	205.9	203.3	191.9	189.7	199.8
Butter value of sweet milk used on farm per cow..... pounds avoirdupois..	6.53	4.8	5.8	8.1	15	5
Produced green cheese per cow.....do....	233.9	289.7	253.1	232.8	246.7	266.9
Produced ripe cheese per cow.....do....	195.5	245	212.6	208	220.1	238.1
Live weight of swine sold per cow.....do....	185.7	214.5	245.7	240.6	231	236.1
Shrink in butter..... per cent.....	.8	.8	.4	3.1	3.4	1.9
Milk required to make 1 pound butter..... pounds.....	28.5	28.2	28	29.5	29.2	28.9
Skim milk required per pound green cheese..... pounds.....	13.5	13.4	13.3	13.4	13.1	13.2
Shrink in cheese..... per cent.....	16.4	12.2	16	10.7	10.8	10.8
Price of butter per pound avoirdupois:						
In summer.....cents.....	21.6	22.8	21.5	22.9	21.6	22.3
In winter.....do.....	25.02	25	25	25.02	27	27
Price per pound avoirdupois of skim-milk cheese.....cents.....	3.15	4.72	4.7	3.97	5.2	5.62
Price per pound of swine (live weight avoirdupois).....cents.....	6.27	5.88	6.41	6.97	7.38	7.63
Receipts from each pound of skim milk:						
In cheese.....cents.....	.2	.31	.29	.26	.35	.42
In whey.....do.....	.098	.11	.11	.15	.19	.198
Total receipts per pound of skim milk.....cents.....	.298	.42	.4	.41	.54	.618
Receipts from each pound sweet milk.....cents.....	1.08	1.10	1.2	1.15	1.3	1.36
Gross receipts per cow.....	\$58.14	\$71.51	\$79.54	\$69.51	\$77.89	\$81.21

VALDEMAR CASTLE.

This old castle is situated on the small island called Tosinge, which lies close to the Isle of Funen. The farm consisted of 630 acres. On this area were kept, at the time of my visit, 120 dairy cows, about half of which were in milk and the other half dry. They were stabled in an excellent barn, the plan of which may be seen in the accompanying illustration (Figs. 20 and 21), which I give as a sample of the barns that are generally found on the large farms.

The barn was built of brick with stone foundation, and was one story high, with a high roof. It was entirely fireproof. The ceiling was of brick laid on iron arches, and the only openings from the inside were

those necessary to admit hay and bedding, which were stored under the roof. At intervals there were brick flues for ventilators, which ran to the crest of the roof, and the roof itself was of tiles. There was no wood in the interior of the structure except the door and window frames. There were no partitions between the stalls, and all the posts were of iron.

Fig. 21 shows a plan of the barn; *a* represents the rows of stalls, and *b* the feed alley between the stalls. The floor of this alley was raised a foot and a half above the floor of the stalls. At both ends of



FIG. 20.—Side view of cattle barn at Valdemar castle.

the barn were loose boxes marked *c*, inclosed with an iron fence. These were, for the most part, used for calves; *m* represents the mangers, which were made of curved tiles laid in cement so that they were perfectly water-tight, and the cattle were watered in these mangers twice daily. At one end of the barn were three feed-bins indicated by *f*, and in the middle of the barn was a short wing which contained the herdsman's room *h*, and a large room for mangels, *n*. The floor of the barn, except the feed alley, was a pavement of squared stones nicely

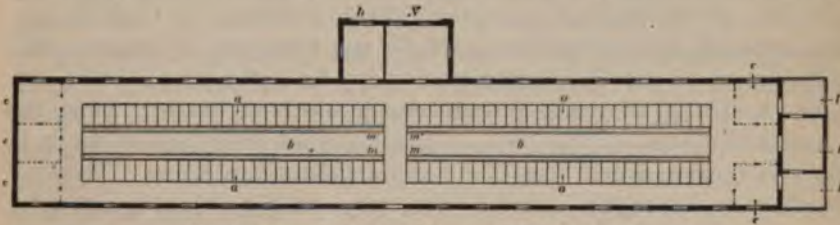


FIG. 21.—Ground plan of cattle barn at Valdemar castle.

fitted together, and provision was made for the drainage of the liquid manure into large cisterns. I did not learn what the cost of this barn was, but it must have been considerable. On the other hand, it was of such a substantial nature that it will last for centuries.

The cows were fed as follows: At 5 a. m. they were fed straw, and the milking took place while this was being eaten; at 7 a. m. each cow got 10 pounds of mangels, and immediately after 5 pounds of grain, consisting of the following mixture: One pound of cocoanut cake, 2 pounds of sunflower cake, 2 pounds of bran, 3 pounds of oats, and 2 pounds of barley, the two latter being ground together. After this was eaten they were watered. Next they got a feed of straw or of chaff. At 12 m. they got a small feed of hay. At 1 p. m. the afternoon feeding began with 10 pounds of roots, then half of the above mix-

ture of grain, and then water. Next straw, and again a feed of straw at 7 p. m. The cows were fine specimens of the red Danish breed. The average yield of milk per cow for the year was 4,950 pounds avoirdupois, including barren cows and heifers. Some of the cows were large milkers, one of them yielding 68 pounds per day.

The milk is handled as follows, according to the statement of the chief dairymaid:

The evening milk is set in tall 50-pound cans, and these are sunk in ice water. These cans are hand skimmed in the morning, and the skim milk is run through the separator, which still produces 4 pounds of cream to 100 pounds of milk. When the milk has been skimmed in this way all the cream is sterilized by being heated to 167° F. This is accomplished by immersing the cream cans in hot water, the sterilizing apparatus being out of order. It is next cooled to about 40° F., at which temperature it remains for a couple of hours. It is then heated again to 78° F., and at this temperature the ferment is added. The ferment in this case consists of sour cream saved from the morning's churning, 20 per cent of this sour cream being added. It then stands in the cream barrel, in a protected place, for eighteen hours, or from noon one day to 6 a. m. the next, when it is churned.

The dairymaid held that this cream ferment had given her better results than any other methods she had tried. In summer she set the cream to sour at only 60° F., but she then added a greater quantity of sour cream, and the same results were obtained. She churned the cream in winter at from 59° to 62° F. and washed the utensils with clean water at 56° F. The butter came, usually, in twenty-five minutes. The revolving dasher in the churn made 140 revolutions per minute. In summer the churning temperature was 52° F. The butter she made was of first quality, and always brought about \$1.35 per 100 pounds over the highest quotation at the exchange in Copenhagen. She added 4½ per cent of salt in winter and 6 per cent in summer, and she assured me that the butter would keep for half a year.

She took the following precautions in packing butter: First, the barrel was soaked for twenty-four hours in cold water and next it was filled with brine, which remained in it for twenty-four hours. Then the inside was thoroughly rubbed with salt. In the meantime paraffin paper was prepared by soaking in brine for several hours, and lastly in saltpeter for a half hour, and the barrel was then lined with this; finally a half inch of salt was put on the bottom of the barrel. The butter was then firmly packed in, the top covered with a sheet of paraffin paper, on top of this half an inch of salt, and then the head was put on. The barrels thus packed were kept in a cool room adjoining the ice house until they were shipped, and each barrel was rolled about for some time once a week in order to prevent the brine from settling too much in one place.

The skim milk was sterilized before it was fed to the calves, and cheese was made from what was left after feeding the calves and taking out what was required for the household. It required 22 pounds of milk to make a pound of butter in summer and fall and 25 pounds in winter.

This farm is situated on the island of Langeland (Longland). I paid a flying visit to it because, in my travels about the country, I had heard the dairy products from this place highly spoken of, and I even heard of the butter from this farm while among the butter dealers in London. My time, however, was so limited that I could only interview the dairy manager, but the establishment owed its reputation chiefly to his skill. He was a young man by the name of Neilsen Holm, who had studied dairying in the best establishments of the country. The following notes were taken from his statements:

There were 250 cows on the farm, and of these 200 were in milk at the time of my visit. The stalls were cleaned in the morning from 3 to 4:30 a. m., and immediately after this the cows were milked. The first feed was given at 7 a. m. and consisted of half a bushel of whole mangels. When these were eaten they were fed grain consisting of 2 pounds of barley and oats ground together, 2 pounds of bran, and 1 pound of rape-seed cake; they were next watered at about 8 a. m., the water being run into the manger in front of them. After the water they got 4 pounds of hay per head, and when this was eaten a liberal feed of barley straw. They were then bedded down, the doors were closed and the stable kept as quiet as possible for the remainder of the forenoon. At 1 p. m. the feeding began again with another half bushel of whole mangels and then 5 pounds of grain of the same mixture as above; next water, hay, and straw in succession as in the forenoon. The stable was again cleaned from 3 to 4:30 p. m. and the milking took place immediately after; finally a feed of straw was given about 7 in the evening.

The herd, as a whole, was first class. Many of the cows gave as much as 6,600 pounds avoirdupois of milk per year. He selected calves intended to be raised to fill places in the herd only from the best cows. Good cows were bought wherever they could be found. The cows were tested by the so-called "trial-milkings," which occurred twice a month. It consists in weighing the milk from each cow separately, at both milkings, on fixed dates, and from this the yield is estimated. The cows were not named but numbered, each being known by her number only. Special attention was also given to the breeding of bulls on this farm, and the few bull calves which, in point of pedigree and individual merits, were considered good enough to raise, sold for high prices. The milk was run through a De Laval "Alpha" separator as soon as it reached the dairy, at a temperature of 86° F., and the cream was at once put in ice water and cooled to 50° F. in the winter, and in summer to 45° F., and was kept at this until time to sour it. It was then warmed to 77° F. and at 10 a. m. put in the cream barrel at this temperature and 5 per cent of ferment added.

The ferment was made thus: Healthy cows were selected which had been in milk about six weeks. This milk was put in ice water as

soon as it arrived at the dairy and cooled to 40° F. Here it remained five hours, and whatever cream rose in that time was skimmed off. The skim milk was then warmed to 100° F. and immediately put aside in large earthenware jars, and these, in winter, kept in a box lined with a hay mattress to keep out the cold. Put away thus at 11 a. m. it remained until the next morning at 8 a. m., when the jars are opened and the upper 2 inches skimmed off to avoid contamination from injurious bacteria which might have found lodging on the surface. The milk, which had become sour, was then thoroughly mixed by being violently stirred and then cooled while exposed to fresh air to 50° or 54° F., and finally, at 10 a. m., it was added to the cream in the cream barrels. Occasionally buttermilk was used as a ferment, but, as a rule, this skim milk ferment was prepared and used daily. After the ferment was added the cream stood from 10 a. m. until 5 a. m. the next morning, but was stirred four times during the day. At 5 a. m. it was transferred to tall cans which were sunk in ice water until the cream showed a temperature of 12° R. (59 F.), at which temperature it was churned in winter. From the 200 cows in milk 330 pounds of cream was obtained daily. The churn was run by steam, the dasher making 140 revolutions per minute, and butter came in from 30 to 35 minutes. The butter received three workings on the machine; after the first working it was weighed and 4 per cent of salt was added; one-half hour later it was worked again, and two to two and a half hours later it received the final working. It was then packed in barrels in the same manner as has already been described. It took 26 pounds of milk to make a pound of butter. The butter was sold by contract to one dealer for the whole year, the agreement being to pay about \$26 per 100 pounds of butter; but for the ensuing year's contract I was informed the price would be raised to about \$30 per 100 pounds. The butter was strictly a first-quality article.

JULESBERG FARM.

I made a brief visit to a large farm of that name situated a short distance from the city of Nyborg. There were 130 cows on the place, but, in addition to the milk from these, milk was bought from some of the smaller farms in the neighborhood, so that the total amount handled was nearly 5,000 pounds daily. The creamery was of the improved type, equipped with all the machinery demanded by the most advanced methods. This milk produced about 195 pounds of butter daily. All the cream was pasteurized before it was fermented. The ferment used was usually produced on the place, from skim milk, in the manner already described, but they also used pure cultures when it was thought advantageous to do so. The dairy was in charge of a woman, who informed me that she churned at 57° F. during the winter, and that the cream was set to sour at from 68° to 72° F., according to the weather, and she used 4½ per cent salt to the butter.

The cows on the farm were fed as follows: They were milked between 4 and 6.30 a. m. This done they got their first feed, which consisted of 4 pounds of a mixture made up of one-half part each of rape-seed cake and cotton-seed cake, and one part each of bran and barley and oats ground together. After this they got a feed of hay, then water, and next straw. This completed the feeding for the forenoon. At 1 p. m. it began again with grain, as above, then 15 pounds of sliced mangels, then two feeds of straw in succession. Of the 130 cows on the place 92 of all ages were in milk, and these gave 1,850 pounds of milk daily, and the best cow gave at that time 48 pounds of milk daily.

In summer the cows were tethered in the pasture. The milking was done by women, each of whom milked 20 cows in two and one-half hours. I found on this farm some 25 or 30 head of steers which were being fattened. They were fed entirely on oil cake and mangels. Each steer got 5 pounds of rape-seed cake daily and all the mangels he would eat, but no water, the mangels supplying water enough for the needs of the system. This mode of fattening is so unusual that I can not forbear to mention it here. The feed-master assured me that they gained about 3 pounds daily, per head, under this treatment. They were of the ordinary dairy breed of the country, and were tied up in the stable, never being let out.

BRAHETROLLEBORG.

This is the country seat of Count Reventlow. The home farm of the estate comprised about 660 acres, about 100 acres of which were in permanent meadow and the rest under culture. The herd consisted of 161 cows and 3 bulls, and 22 horses were used to work the farm. The cattle got their first feed at 4 o'clock in the morning and while they ate this the milking took place. The second feed was given at 6:30 in the morning, consisting of three pounds of barley and oats ground together, 2 pounds of bran, 1 pound of rape-seed cake and one pound of palm cake. They were next watered in the mangers, after which they got a feed of chaff, and when this was eaten they had a feed of oat or barley straw, which completed the feeding for the forenoon. At 1 p. m. they were again given grain, water, chaff, and hay in succession, and finally a feed of straw in the evening. The milking began at 4 a. m., the stable being cleaned before milking. The bulls had each 4 pounds of grain per day and straw and hay, as the cows. No roots were fed upon this place. At the time of my visit 82 cows were in milk, which yielded about 1,450 pounds milk per day. They still used the old system of setting the milk in cold water, where it stood twenty-four hours before it was skimmed. The cream was then warmed to 68° F. and soured by the use of buttermilk from last churning. Pure culture cream ferment was used when necessary. The cream stood 24 hours after the buttermilk was added. They also occasionally made fresh ferment from skim milk in the manner already described

elsewhere. From the amount of milk given they obtained 57 pounds of butter daily. The butter was worked three times, four per cent of salt being added at the first working. The price realized from the sale of the butter was somewhat less than that of some of the other places I have noted.

Cheese was made from the skim milk by the following process: The milk was warmed to 95° F. in winter and 92° in summer, and prepared rennet added when the temperature was reached. It then stood undisturbed for three-quarters of an hour, when the curd was cut and slowly stirred for twenty minutes, until the whey became clear. It then rested for ten minutes, after which it was again stirred a little and when the whey was perfectly clear it was drawn off and the curd pressed with the hands in the cheese vat, to work off the whey. Salt and caraway seed were then added. This completed, it was transferred to the cheese cups and put under the press, the pressure being light at first. At the end of an hour the cheese was turned in the cups and replaced under the press, where it remained until next morning, but it was turned twice more in the meantime. On being removed from the press the cheeses were put in strong brine, where they remained for twenty-four hours, and they were then put in the cheese room, where the temperature was kept at about 54° F. Here they were turned daily and each time wiped with a dry cloth, this process being continued until they were thoroughly dry. They were kept for at least two months and sometimes much longer, according to the market. The dairy was in charge of a superintendent, to whom I am indebted for these facts. He stated, further, that he made a pound of green cheese from 11 pounds of milk, and that his cheese shrank 15 per cent in weight in the process of drying.

On this farm were 20 head of high-grade shorthorn heifers, 3 and 4 years old, being fattened for market. They were in extra fine condition and estimated to average about 1,600 pounds in weight. They were tied up in the barn, as the dairy cows, and were never let out, being fed and watered in the stalls. They had been on good pasture without grain during the summer and when put in the stable in the fall they were fed hay and straw, turnips and kohlrabi, all they would eat, but no grain. This treatment was continued for one month, then 2 pounds of linseed cake was added to the ration. During the next month this was increased to 6 pounds per head, and in addition some of the largest got 2 pounds of barley and oats.

SMALL DAIRY FARMS.

In the following account I shall briefly describe the processes, both in the dairy and in the cultivation of the soil, which are followed on the small Danish farms. Possibly they may furnish hints of greater usefulness to the majority of farmers in the United States than do those of the large farms. There are but few farms in this country where one

hundred or even fifty dairy cows are kept, and fewer still where the dairy is fully equipped with all the modern machinery. Here the farm dairy is on a small scale, and as to material and practical methods of work, it therefore comes nearer the small Danish farms.

FARM OF MADAME NIELSEN.

One of the first of this class of farms which it was my privilege to visit is situated an hour's ride on the railway from Copenhagen and belongs to Madame Nielsen, who named it Havarthigaard. This lady is known outside of Denmark for her dairy products. For nearly thirty-five years she has been a close student of dairying, both at home and abroad, having made several trips to various European countries

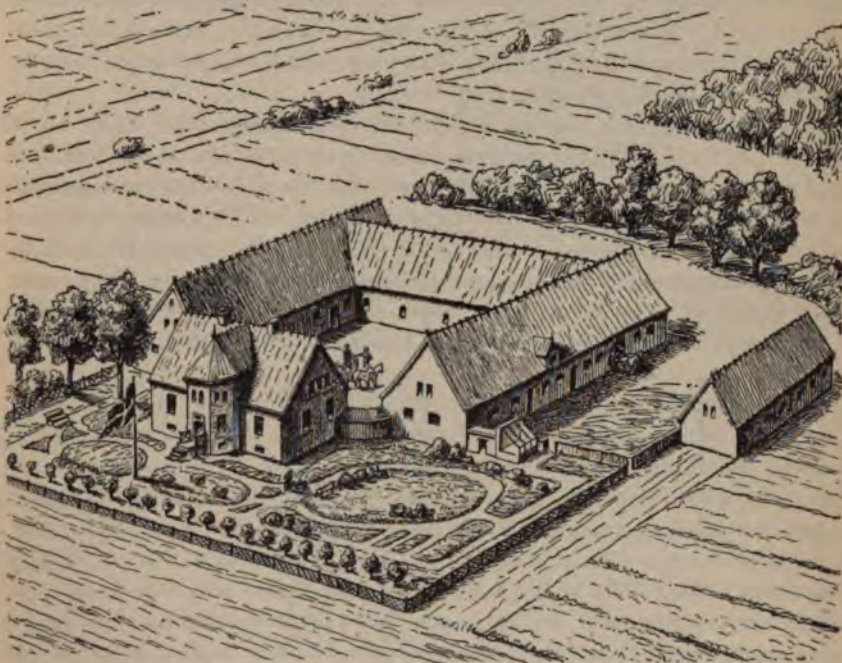


FIG. 22.—Perspective of Madame Nielsen's buildings.

in order to study their methods and obtain points which she could apply to her own practice. She has thus visited England, Holland, Switzerland, Norway, and France at various times. She has met with signal success. She supplies the butter for the table of the King and Queen, a few pounds being sent to the palace by express every morning from her house. In cheese-making she is equally successful. Her cheese sells for many times the price obtained for ordinary cheese. She even sends cheese to the Emperor of Russia, who learned to appreciate her dairy products on his visits to Copenhagen. He usually carries home a supply when returning from one of these visits, and consignments are occasionally sent to the palace in St. Petersburg.

Most of her produce, both butter and cheese, is sold to special high-class customers, and the surplus not sold in this manner is disposed of in a little shop in the exhibition building in Copenhagen, where she herself waits upon customers every afternoon. She is famous not only as a practical dairywoman but as a teacher of dairying as well. She informed me that she had instructed no fewer than 1,000 pupils in her dairy methods. It is quite the thing for young persons of both sexes, who have completed their course in dairying elsewhere, to finish up with a few weeks or a few months with Madame Nielsen, and many of the chief dairywomen that I met elsewhere had, at some time or other, been at her establishment. She charges a good round fee of them, usually about \$27, whether they stay for a long or short time, and while there, by the terms of the agreement, they do the work in the dairy of whatever kind. At the time of my visit, in January, there were four young ladies studying dairying, and I was informed that by the first of March two more were to come.

The farm on which she has developed this famous little dairy is 166 acres in extent. The farm management is in the hands of her husband and son-in-law, who, with his wife, lives with them; but the management of the dairy cows and of the dairy is all under her own supervision. I obtained an introduction to this lady through Prof. Segelcke, and by special arrangement it was agreed that I should visit her place, stay over night, so as to be on hand early in the morning, when I might have the privilege of learning what I could of what was going on about me.

At the time of my visit she had 19 cows giving milk, the total number in the herd being between 25 and 30 cows. The milking began at 4:30 in the morning and was done by the pupils. The cows were not fed until 6:30, when they got a feed of 3 pounds of grain, consisting of a mixture of bran, barley, and oats ground together in equal quantities, and three-fourths of a pound of rape-seed cake, which was soaked in water for twenty-four hours previously and mixed with the grain. In half to three-fourths of an hour each cow had three-fourths of a bushel of mangels. At 8 a. m. they received a big feed of barley straw or oat straw, the surplus not eaten being used for bedding. At 11 a. m. they were watered in the manger, after which they had a feed of hay, all they could eat. This finished the feeding for the forenoon. They were not fed again until 5 p. m., when they had the same amount of grain as above and after that all the straw they could eat and later water, but no mangels or hay was given them in the afternoon.

In the beginning of May the cows are put on pasture for two or three weeks, but as soon as the grass gets tall enough to cut they are again stabled and stall-fed on green fodder until after harvest, when they are again let out for five or six weeks. They are not tethered, as is the usual custom, but run loose when they are out. The cows were of the red Danish breed, and there were several excellent animals

among them. Ten or twelve heifer calves are raised every year, those not wanted to take the place of older cows being sold.

The calves are fed during the first two weeks of their lives on whole milk; but at the end of this time skim milk is mixed with the whole milk, gradually increasing the skim milk until they get no whole milk at all, and when about ten weeks old the skim milk is partly substituted by whey and bran. This, with hay and straw in winter and grass in the summer, forms the diet of the calves. The following winter they get roots in addition to hay and straw and a little grain. The heifers are bred when fifteen months old so as to drop the first calf when two years of age. Twice a month there is a trial milking, when the milk from each cow is weighed separately, but for the rest of the time all the milk is weighed together.

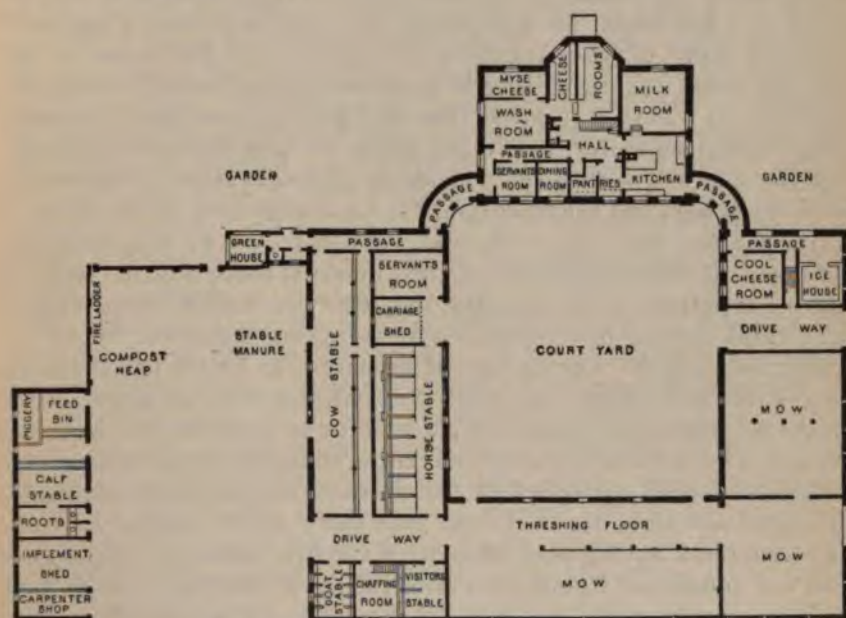


FIG. 23.—Madame Nielsen's buildings—plan of basement.

Madame Nielsen's dairy, I found, was small and by no means of a style which is unattainable by American farmers. It was all in the basement (Fig. 23) under the dwelling house. The milk was set in tall cylindrical cans, and these sunk in ice water, there being several basins constructed of brick laid in cement for the purpose of holding this ice water. The kitchen adjoined the milk-room, and most of the work in butter and cheese making was done in the kitchen. The milk stood twenty-four hours before it was skimmed. As only about 300 pounds of milk were handled per day during the winter, no separator was needed, nor was any sterilizing apparatus used; all the work was done in the good old-fashioned way and with the best results. The utmost cleanliness

was apparent everywhere. All the utensils were scoured and scrubbed until they fairly shone. The floors were clean. Care was used in the ventilation to let in all the fresh air possible and still maintain the desired temperature, and pure water and ice were used in abundance. The cream, when skimmed from the milk, was put in an earthenware jar scrupulously clean. She used in souring the cream a ferment that she makes from skim milk. She used milk from a cow nearly fresh. This stood twelve hours and was then skimmed. It was then warmed to 100° or 105° F., and set away in a place where the temperature could be kept moderately uniform, where it remained twenty-four hours. At the end of this time it developed the proper degree of sourness, the temperature in the winter, in the meantime, having fallen to 68° or 70° F. Some 5 per cent of this prepared ferment was added to the cream about the middle of the forenoon, the cream being first warmed to 75° F. The cream jar was packed in a box lined with a hay mattress, in order to prevent cooling too rapidly. In the course of the day the cream was stirred several times and in the evening it began to thicken. It was then removed from the hay box and kept at a somewhat cooler temperature over night, and at 5 o'clock the following morning the churn was started. The churning temperature varies greatly with the season and the condition. It may range from 55° to 75° F.

When I was there the cream was warmed to 61° F. The churning was done by hand by the side of the kitchen stove in a little churn of the usual pattern of the country, the revolving dasher being turned by a crank and the power supplied by the muscular arms of one of the young lady pupils. On the sign of formation of butter the churning proceeded more slowly, and when the granules were as large as pin heads the churn was washed down with water at about 50° F. Madame Nielsen herself takes the butter out of the churn and works it in an old-fashioned wooden butter trough, but she never touches it with her hands. It was worked three times at brief intervals. At the second working, the buttermilk having been removed at the first working, 4 per cent of salt was added, and immediately after the third working it was packed in china crocks for transmission by express to the several special customers.

The method of souring the cream here described was not her invariable practice, however. Sometimes she would warm the cream in an enameled kettle to 84° F., after which she would add 5 per cent of buttermilk from the last churning. This would stand for three or four hours in the cream jar until the temperature of the cream had fallen to 66° or 68° F., when it was transferred to the hay-lined box to maintain this temperature as nearly as possible, and it remained there until bedtime, when it had begun to thicken. If the box should then afford too much warmth the jar was taken out and set on the floor or in water, according to circumstances, until morning. She attached special importance to the following points:

- (1) That the churning temperature was properly adjusted to the season

and the quality of the cream, as this might be affected by the feed of the cows, or the number of fresh cows in the herd, and other varying conditions; (2) that the fermentation of the cream began at a relatively high degree of warmth; (3) that the temperature of the cream was gradually reduced during the time that the ferment was acting; and (4) that the cream thus treated should stand for some time (over night) at the temperature of about 50° F. before it was churned. In the morning the cream was warmed to the proper temperature for churning by setting the cream jar in warm water. By this method she claimed to be able always to produce the finest quality of butter. She had not, as yet, found it necessary to use the pure cultures in the fermentation of her cream.

Simultaneously with the churning, preparations were made for the making of cheese. She made three kinds of cheese while I was there, sweet-milk cheese, Camembert cheese, and Myse cheese, and occasionally she made some half dozen other kinds of cheese, in all of which she was very expert. The sweet-milk cheese was begun first. As soon as the milk was received from the barn and it had been weighed and strained, it was warmed to 88° F. by setting the cans of milk in kettles of warm water on the stove. To a hundred pounds of sweet milk she added 64 pounds of skim milk, so it was not strictly a full-cream cheese. When the milk had reached the temperature of 88° F. the rennet was added.

She used rennet at the rate of two one-hundredths of a pound of the fluid extract to 100 pounds of milk. A little buttermilk was added along with the rennet. It was then allowed to stand undisturbed for twenty-five minutes, at the end of which time it had coagulated, when it was cut with a curd knife. After this it was gently stirred to clear the whey, and if the temperature had fallen during the interval it was warmed a little during the process of stirring. When the curd had settled to the bottom the whey was drawn off and the lump of curd quartered and the outside turned into the middle of the vat in order, as she stated, to drain it equally and make it of the same consistency throughout; otherwise it would have been firmer in the middle. When the whey had drained off, the curd was broken into large pieces by hand and these were packed in the cheese cup with layers of caraway seed. No salt was added, as it gets enough of that substance during the process of curing.

The form of the cheese cup should be mentioned. It could be enlarged by the addition of rings, and as the cheese was compressed and required less room these rings were removed. When the cup was filled it was placed under the cheese press, but only a very light pressure was applied. It was put in press at 9 a. m. usually, and at 9:30 the cheese was turned and pricked through and through with a prong. It was again turned at 11 and again soon after noon, at 4 p. m., and at 9 p. m., but remained in the press until the following morning. It was then removed

from the cup, rubbed with salt and put in a wooden bowl with a rounded bottom, where it stood for some time in order that the sharp edges might be removed and the cheese take a rounded shape. It was rubbed with salt and turned in this bowl three times a day for four days; then it was put in the cheese room and rubbed with salt once a day. This was continued for six weeks; it was then changed to another room of a slightly cooler temperature and rubbed with brine once every other day, which process was continued until the cheese was sold. She attached great importance to this frequent rubbing with salt. It not only makes the rind soft and practically prevents the formation of any rind whatever, but she called my attention to the fact that her cheese was covered with a fatty layer, which she said was drawn out by the salt, and which effectually prevented the access of air to the interior of the cheese. It is a well-known fact that the best cheese is cured in the absence of air in the interior. She made, at that time of the year, only one cheese of 16 pounds' weight per day. After about three months' curing, or longer, the cheese was sold, and it brought about 25 cents per pound, when the ordinary skim-milk cheese brought but from 4 to 5 cents per pound.

Camembert cheese is a kind of specially rich cheese which she makes from whole sweet milk every morning, as soon as the milk is drawn from the cows, weighed, and strained. It was my privilege to assist in making this cheese. The process was as follows: The fresh milk, warm from the cow, was warmed to 100° F. At this temperature she added one one-hundredth pound of rennet for each 10 pounds of milk, after which it was gently stirred, and then allowed to stand for four and one-half hours, when it had coagulated to the proper degree. The cheese vat used was a large earthen jar, which was kept wrapped up and placed near the stove so as to maintain the same temperature of 100° F. until coagulation was completed. The curd was then cut into small squares, but not worked or pressed in the least. When cut sufficiently fine, curd and whey together were dipped out and put in small tin rings or molds with holes in the sides, but with neither bottom nor top. Each form, or mold, consisted of two rings, one placed on top of the other, and when thus arranged they were about 6 inches high and measured 5 inches in diameter. They rested on a strainer placed on top of a vessel, and over the strainer was laid a little mat made of clean, stiff, rye straws, single straws being tied parallel to each other. This was to drain off the whey, and the straw mats facilitated the turning of the cheese. When the cups were full they were left undisturbed for eight hours in a warm place near the stove. By the end of that time the cheese had settled so much that the upper ring or half of the mold was removed and the cheese was turned, but left in the cup over night. Next morning they were turned again and salted on one side. Three or four hours later they were again turned and salted on the other side. No pressure was applied at any time. During all this time the temperature did not fall below

78° F. After the second salting it had acquired sufficient solidity to be removed from the mold. It was then placed in a room with the temperature from 55° to 60° F., where it remained for two or three weeks, when it was placed in the cheese room with a somewhat higher temperature. It was ready for sale when two months old, and sold at 1 crown, or 27 cents, apiece and weighed three-fourths of a pound. She made about fourteen cheeses daily of this kind, from 80 pounds of milk, the total weight being 10 pounds of cheese. Some cream was sometimes added to the milk before it was curdled, if she had the cream to spare.

Myse cheese is made of the solid matter left in the whey after the water has been evaporated. It consists chiefly of milk-sugar, with most of the ash elements of the milk, and the albumen and fat not removed in cheese-making. It originated in Norway, where they use the milk of goats chiefly, which is said to produce the finest quality. But it can be made from any kind of whey, sweet milk, or skim milk, and, as a matter of fact, is so made. It therefore varies greatly in composition. Mr. Bøggild makes, on the authority of a Norwegian chemist named Werenskjold, the statement, that Norwegian Myse cheese will vary in composition as follows: Water, from 24 to 38 per cent; ash, from $5\frac{1}{2}$ to $6\frac{1}{4}$ per cent; fat, from 1 to 10 per cent; lactic acid, from $\frac{1}{10}$ to $\frac{1}{2}$ per cent; albuminoids, from $6\frac{1}{2}$ to 9 per cent, and other substances, consisting chiefly of milk sugar, from 46 to 61 per cent.

Madame Nielsen allowed nothing to go to waste. Every morning the whey, which was obtained from her sweet milk and her Camembert cheese, was made into Myse cheese and, to give it the genuine flavor, she kept half a dozen goats, whose milk also contributed to it. As soon as all the whey was collected it was divided between half a dozen enameled pots, each holding several gallons, and these were placed over the cook stove and here the whey was evaporated, being constantly kept at the boiling point while it was continuously and violently stirred. This kept all her pupils busy for a couple of hours. As the whey evaporated, so that the contents in the pot became less, it was poured into an adjoining pot until there was only one kettle over the fire. As the mass thickened the stirring increased, and finally it became so thick that it could no longer be prevented from burning. It was then put into a trough, where it was pounded and beaten with wooden clubs like potato mashers, with all the might the young ladies possessed and, when made perfectly homogeneous, it was tamped closely into a square wooden mold and put under pressure. It forms a greenish-yellow, sweetish mass, rather agreeable to the taste and very nutritious. No rennet is added, nor any flavoring whatever. It is ready to eat as soon as it comes out of the mold, but it will also keep for a couple of months. It should be kept in a covered vessel to prevent it from drying up. This cheese sold at the same price as the sweet-milk

cheese. During the summer season she made also Chester cheese, Gorkonsola, Edam cheese, and other kinds.

There is a lesson to be learned from this remarkable woman. With no advantages in education or resources above those possessed by the vast majority of her sisters, she has, by devoting herself to the household arts with energy and skill, attained not only an international reputation, but has accumulated a comfortable little fortune. Fig. 22 shows a perspective of her house and barns, and Fig. 23 a plan of the same, in which the dairy rooms are pointed out.

FARM OF P. PEDERSEN.

I will next briefly describe a small place which I visited in the village of Söllinge, on the island of Funen. The place is owned by a school teacher, Mr. P. Pedersen, who teaches school daily in addition to overseeing the work on his little farm. The property consists of 7 acres, which he described to me as a soil of ordinary quality with a clay subsoil. He has owned it since 1876. About one acre was occupied with buildings and garden; the garden was closely planted with apples, pears, cherries, and between these gooseberries, currants, and raspberries. The remaining 6 acres were divided into five lots, one-fifth being in perpetual meadow. The other four parts are cultivated as follows, in a four-year rotation: The first year, one-third of one of these quarters was in rye or wheat, one-third in some soiling crop, chiefly a mixture of vetches and oats, and one-third was given up to the production of seed of turnips, mangels, and cabbage. A second quarter of the small farm was given up to roots for the cattle, potatoes, and green peas, the latter being raised for market. Of the third quarter, two-thirds was sown in barley or a mixture of barley and oats, which was used for feed, and one-third was given up to a variety of vegetables. The last quarter was two-thirds in grass and one-third in vegetables. This rotation was followed constantly; thus, the quarter with rye and soiling crops one year was the next year planted with roots, potatoes, and green peas; the third year with barley and vegetables, and the fourth year with grass and vegetables. High manuring and thorough culture make it possible to keep four high-class dairy cows and one heifer on this very small farm.

Every particle of manure was saved. The liquid manure was collected in a cistern and applied to the grass land, to the fruit trees, and plats devoted to seed growing, and the solid manure was applied to the root crops, the soiling crops, and to the vegetables. Besides the cows he kept two brood sows and yearly fattened 8 or 10 head of swine, all from the products of this little place. But with all this live stock, which produced considerable manure, he informed me that he still bought yearly 200 pounds of kainit, 400 pounds of Thomas slag, and 200 pounds of Chile saltpeter, which were applied to the grain crops. The dairy cows were fed grain both summer and winter. The winter ration

lies here for at least two hours in the cold season, and when the weather is warm it may lie for eight or ten hours, or even until in the cool of the following morning, before it receives the final working. The object is, not only to cool the butter, and thus allow it to become firmer, but also to allow the salt to dissolve and to penetrate the whole mass. When it has attained the proper degree of firmness it is again put under the butter-worker, and the last buttermilk and a considerable portion of the brine formed from the salt is worked out. How much working it can stand differs much in individual cases. Care is taken, however, that it is not the least bit overworked so as to become greasy and sticky. This working may be repeated a couple of times, or it may be packed for shipment at once; practice is not uniform on this point. It is common, however, to give it one more working an hour or two later. The main point is not to work it until it has become decidedly firm, and then work it only to the extent it can bear without injuring the grain, and yet remove as much as possible of the brine which has formed from the dissolving salt. It is worthy of notice that although 4 per cent of salt may be added, with proper working about half of this is removed in the form of brine.

PACKING FOR MARKET.

The Danish butter is invariably packed in barrels. These may vary in size according to the demands of the market, but they are always of the same pattern. One of these barrels and the wooden mallet used to pack the butter firmly in it are represented in the accompanying illustration (Fig. 19). The most usual size is one which will contain an English hundredweight (112 pounds), but this size is not uniform. These barrels are usually manufactured on the farm where they are to be used, the "feed-master" combining with this important office the trade of a cooper. While the cows are eating he makes the butter barrels. These barrels are usually made of beech wood. The European beech wood is white, fine grained and hard, and of course it is thoroughly seasoned. The staves are held together by wooden hoops and the barrel is made perfectly smooth inside. The day before it is to be filled with butter it is first thoroughly scrubbed in scalding water and next filled with clean cold water, which remains standing in it until a short time before it is wanted. It is next rubbed with salt all over the inside, letting as much as possible adhere to the sides. The bottom and sides are next lined with paraffin paper to prevent the butter coming into contact with the wood. Then the butter is packed in lumps of 10



FIG. 19.—Barrel in which butter is packed for market.

and 12 pounds, and by the use of the mallet it is pressed firmly down in order to prevent any openings in it. This process is continued until the barrel is full. It is filled slightly higher than will permit the putting on of the lid, and with a sharp, flat spoon the excess is cut off to just the point required to admit the lid. Now a sheet of paraffin paper is put over it and this is covered with a thin layer of fine salt. The lid is then put on, the hoops tightened, and the barrel is ready for market. During the time it remains in the creamery it is placed in a cool storeroom, usually adjacent to the ice house, until enough has been collected for shipment to the dealer. It is customary in most dairies to ship their export butter to the agent about once a week.

USE OF SKIM MILK AND BUTTERMILK.

Much of the skim milk is used for cheese. Considerable is also used in the household, and what is not used for these purposes is fed to calves and pigs. It is customary in feeding calves to gradually substitute skim milk for whole milk, after the first two weeks. As the older cows drop out of the herd, or cease to be profitable, their places are taken by young stock raised on the place. It is customary, also, to keep a number of swine, which are fed, for the most part, on the offal from the dairy. In the coöperative dairies the farmers who furnish the milk take back the skim milk, this being, in most cases, a part of the contract, and in some cases the buttermilk is in like manner returned to the producer at a moderate valuation. These products are then used in the same manner as on the larger farms. Near the towns there is always a good market for skim milk among the poor people, who can buy it at a low rate. It will thus be seen that nothing is wasted, everything is utilized, and it is to be noted that the skim milk is returned to the producer while it is sweet. In no case did I find the stinking skim-milk reservoir which seems to be a fixture in American creameries, and from which our farmers help themselves. The skim milk is also fed to colts with good results.

DESCRIPTION OF PLACES VISITED.

In what follows I shall attempt to give some idea of the methods followed on Danish dairy farms, both in the dairy and in the production of crops. Of course many details have been overlooked, but it is hoped that enough has been gathered to give the reader a fairly correct notion of the system manifest in the work, and the care given to details. I was compelled, for lack of time, to confine myself to the salient points in farming methods. Had more time been at my disposal it would have been possible to have gone more into details, but I could usually spend only one day at a place, and this, too, at a season when there was practically no farm work going on.

THE MILK-SUPPLY COMPANY OF COPENHAGEN.

I took early occasion to visit the city milk-supply station of Copenhagen, which I shall briefly describe. I am aware that it has already been partially described in our agricultural press, but it is an institution of such extraordinary interest, owing to the methods there adopted in handling milk, that it will bear further mention, and should serve as the worthy example for our many large cities to follow. It is in the hands and under the exclusive control of a private organization. Neither the Government nor city has anything whatever to do with it. It should also be explained that it does not by any means supply all the milk consumed in Copenhagen. Just what part it supplies of the total amount consumed in the city I am unable to state, but it is considerably less than one-fourth. The Milk-supply Company of Copenhagen is simply an organization which has taken upon itself to supply its patrons with absolutely pure and wholesome milk at a slightly advanced price above what milk can be bought for from the numerous other sources of supply. The company began business some fifteen years ago on a small scale, but for the month of December, 1879, the daily sales averaged 9,733 Danish pounds (10,728 pounds avoirdupois), and for December, 1892, 36,194 Danish pounds (39,896 pounds avoirdupois), and this at the season when milk is scarcest. The merit of the system consists, first, in the strict rules which have been laid down concerning the quality of the milk; second, in the painstaking cleanliness which obtains in the handling of the milk; and, third, in the unflinching enforcement of the rules mentioned. Each dairy farmer of whom the company buys the milk must agree to conform to the following requirements in every particular:

(1) The feed must be such that it does not affect the taste or character of the milk injuriously. The use of distillery slop and like substances for feed is absolutely prohibited, and the use of all feed that has been injured or is not well preserved. The use of turnips, kohlrabi, rutabagas, and the leaves of all kinds of root crops is prohibited. Carrots and mangels may be used to the extent of half a bushel per day for each cow, but only when the grain feed given amounts to 7 pounds per day. Cows which supply milk for the use of children must not be fed mangels and carrots beyond the extent of 1 peck per day. Oil cake (rape-seed cakes) may be fed to the extent of but 1½ pounds per day, and this only in connection with at least 5 pounds of grain feed. Cows supplying milk for the use of children must not be fed oil cake of any kind. For other cows the grain mixture used shall receive the company's approval before delivery of milk can begin.

(2) In the summer time the cows must not be fed in the barn under any conditions. They must be pastured on clover and grass. Vetches must not be used. When necessary, arrangements may be made with the company for the use of grain or green grain crops during the summer.

(3) The cows must be clipped on the udder, tail, and hind quarters in the fall before they are put in the barn.

(4) The time of calving of cows in the herd must be distributed as evenly as possible through the year, so that the amount of milk delivered, especially during September and October, shall not be less than two-thirds of the greatest amount delivered in any month.

(5) Fresh milk up to twelve days after calving must not be delivered, nor will the company receive milk from cows which give less than 6 pounds per day.

(6) The utmost cleanliness must be observed in milking, and the milk must be strained through a metal strainer covered with a clean woolen cloth.

(7) There must be at the disposal of the dairy at least 30 pounds of ice for every 100 pounds of milk produced on the farm.

(8) Every dairy must be supplied with a Lawrence milk-cooler. This may be rented from the company if desired.

(9) As soon as it is drawn from the cow, the milk must be cooled by the use of ice water on the milk cooler, and this at all seasons of the year. This cooling should reduce the temperature of the milk to at least 4° Réaumur (41° F.) before it is shipped.

(10) The milk must be delivered at the railway station once or twice daily, as the company may desire, either as sweet milk or as half-skimmed milk and cream. It must not be sent from the dairy farm sooner than necessary to make the train, and in summer the delivery wagon must be covered so as to shade the cans.

(11) The company will supply the cans used for transportation, and they will be cleaned before they are shipped to the dairy farm.

(12) The cans must be rinsed in cold water immediately on their arrival at the dairy. They must be kept in an airy place, protected from all dirt, with the lids removed and opening downward, but so that the air has free access to the interior, until they are used.

(13) The can must under no circumstances be used for anything else than the transportation of milk.

(14) The dairy farmer must agree to answer all questions which the company may put to him concerning the milk.

(15) The dairy farmer must permit one of the company's veterinarians to examine his cattle whenever he chooses, and must carry out the directions which the latter may give him. He must also agree to furnish transportation for the veterinarian to and from the railroad station.

(16) Cows which the veterinarian finds have tuberculosis must be removed from the herd at once and disposed of as soon as possible.

(17) Cows which are taken with any suspicious disease must be removed from the herd at once and the company informed of the fact, and, if necessary, the delivery of milk may be stopped until the veterinarian has had opportunity to examine the case. But in such cases the company will pay for the milk at the same rate as though it were delivered.

(18) If any contagious disease occurs among the persons who live on the farm, or at the homes of the laborers who work on the farm, it shall be the duty of the dairyman to inform the company of the fact at once. The milk will, in such cases, be paid for at the usual rate.

(19) This contract may be terminated either by the company or the dairyman on the first day of any year, but with at least six months' notice.

(20) Should the milk be found to be of such an inferior quality as to be unfit for sale, the company reserves the right to stop its delivery without remuneration.

(21) If the sale of milk in Copenhagen should be stopped by reason of an epidemic or other non-preventable cause, the delivery must be stopped for a shorter or longer period without remuneration.

This very strict code is observed to the letter. At present the company receives milk from 42 dairy farms, representing in round numbers 4,600 milch cows. To watch the health of these cows the company employs three skilled veterinarians, who spend all their time in traveling from farm to farm in order to examine periodically each individual in the herds, and also to see that the rules as regards feeding,

etc., are observed. When an animal is found to be suffering from any sort of disease, it is withdrawn at once. And should a disease occur suddenly the dairyman is encouraged in withdrawing of his own accord the animals so affected, and is paid the price of the milk which they give until one of the company's veterinarians can pass judgment on the case.

In addition to this the company employs a staff of trained dairy-maids who travel from farm to farm, call unexpectedly, examine the surrounding conditions with special reference to cleanliness and care in milking, watch the feeding, the cooling of the milk, etc., and then promptly report the facts they obtain to the company on blanks furnished them for the purpose. On some of the larger farms such dairy-maids are permanently located, the company paying the dairymen for their board. At present there are four such dairywomen located on as many farms. But the inspection does not end here. At the receiving station in Copenhagen a sample of the milk from each farm is taken immediately on its arrival and subjected to the Babcock test, a large machine of this pattern having been procured for that purpose a short time ago, and once or twice a month similar samples are subjected to chemical analysis. Moreover, when the sample is taken an experienced dairywoman stands by, who tastes and smells of the milk from each farm, and who quickly notes whether it falls below the high standard that is required.

I spent a night and the greater part of two days at the company's receiving and distributing station in order to watch its operations. Including the drivers of delivery wagons and the boys who assist them by carrying the milk from the wagon to the house, the number of employees is about 250. The milk is shipped to the city in the evening. The trains begin to arrive about 9 p. m., and continue until after midnight. The milk is at once hauled to this receiving station or dairy, where it is weighed, sampled, tasted, and the cans deposited in large vats of ice water, where they remain till 4 a. m., when the delivery wagons begin to make ready.

The cans are of tin, made very massive, and hold about 100 pounds each. Two forms are used, one round, the other square. The round cans are used for the unskimmed milk and the square cans for the half-skimmed milk. Otherwise they are shaped like a jug, with contracted neck, into which a lid fits very closely. In the interior of the cans for unskimmed milk is an arrangement intended to equalize the distribution of the cream with the milk. It will be seen that when a can of sweet milk stands on a delivery wagon several hours the upper stratum of milk must be richer in cream than the lower stratum, and that if the milk is drawn from the bottom the first customer will practically get skim-milk and the last cream. To prevent such injustice, the tube, or pipe, in which the discharge valve is placed is continued clear to the top of the can on the inside, and a row of small holes the whole length

of this tube admits the milk. Now, when the valve is opened, the milk is drawn neither from the bottom nor top of the can, exclusively, but through these small holes in the tube—from the whole side of the can from bottom to top, or as high as the milk may reach, equally. The weight of each can is stamped upon a brass plate which is soldered to the top of the can. This greatly facilitates weighing. Before leaving the farm each can is sealed with a cord and a piece of lead stamped with a punch, in the same manner as our railroad freight cars are sealed. This precludes all possibility of tampering with the contents in transit, and a label bearing the name of the farm in large print is also pasted on each can.

The company supplies its customers with three grades of milk, namely, whole milk, half skim milk, and milk for children, and with two grades of cream, designated respectively as first and second grade. The skim milk received, and for which there is a large demand for use in cooking, is in most cases the morning's milk which has stood ten to twelve hours before shipment. The cream that may have risen is then skimmed off and shipped in separate cans. The children's milk is intended as food for infants. For this supply special cows are picked by the company's veterinarians, and these are fed somewhat differently, or at least with greater care than the others, and their milk is kept separate. This milk is filtered and bottled and the bottles sealed immediately on arrival, and not allowed to stand in the cans till morning, as is the other milk. The ordinary whole and skim milk is also filtered before it goes to the customer, but this is done at 4 a. m., just before it is loaded into the delivery wagons.

The filtering machines are of special interest. There are several of them, and they vary somewhat in size, but otherwise the construction is the same. Imagine a large bowl of enameled iron with a capacity of about 40 gallons, and this raised on supports about 5 feet from the floor. There is a hole in the bottom through which the milk enters, and near the rim are two discharge pipes, one on each side of the bowl. Now, the filtering material consists of three layers of gravel and six thicknesses of fine muslin stretched over a ring that fits closely inside the bowl and is placed above the upper layer of gravel. The gravel is of three grades of fineness. The lower is about the size of buckshot, the middle layer finer still, and the upper layer as fine as small pinheads. Each layer rests upon a tin plate, perforated with many fine holes, and which fits closely to the sides of the bowl. Each layer is about 2 inches thick, and there is a space of an inch from the top of one layer to the tin plate which supports the next layer above. The milk is poured into a large reservoir which stands somewhat higher than the filter. A brass pipe leads from the bottom of this reservoir to the bottom of the filter bowl. The pressure thus attained forces the milk through the successive layers of gravel and the six thicknesses of cloth, and when it rises to the discharge pipes it runs off through these into the

vessels placed for its reception. Such treatment throughout assures the customer that it is absolutely pure, clean, and wholesome.

Probably no other city in the world is blessed with so thorough a system of control as regards the quality of the milk. And be it noted that it is not done under compulsion of law, but as a piece of business enterprise in private hands. The constitution of the company forbids a greater dividend than 5 per cent, and the price to the consumer is regulated on this basis. It further prohibits the two principal directors from having any financial interest in the company which might tempt them to work for greater profits. The prices paid to the producer for the milk are as follows: From the 1st of April to the 1st of September 20 öre* per "Kande" (2 kilograms=4,409 pounds avoirdupois), which is very nearly \$1.25 per hundred pounds avoirdupois. From September 1 to December 16, 26 öre per 2 kilograms, or \$1.61 per 100 pounds, and from December 16 to April 1, 22 öre per 2 kilograms, or \$1.36 per 100 pounds. This is for the ordinary sweet milk. Milk for children costs rather more and skim milk correspondingly less. The company retails this milk from its wagons in the street at the following rates: Milk for children at 10 öre per half kilogram, ordinary milk at 8 öre per half kilogram, and skim milk and buttermilk at 4 öre per half kilogram, which is approximately 5½ cents per quart for children's milk, 4½ cents per quart for sweet milk, and 2½ cents per quart for skim-milk and buttermilk. The cream is sold at 27 cents per quart for first quality and 16½ cents per quart for second quality. The cream which is not sold is made into butter, and in like manner the whole milk which is returned from the wagons is creamed and the skim milk resulting sold to poor people at half price.

Pay of employees—Their method of treating their employees is interesting, to say the least, and I think it contains a lesson not unworthy the attention of employers of this country. The company has in its employ, altogether, some 250 persons. Most of these are drivers of milk wagons and drivers' assistants, boys who carry the milk from the wagon to the house; but there are also a number of skilled dairy people, clerks, etc. The pay of all is graded to the character of the work; but it is the policy of the company to retain faithful servants as long as possible, and this they do by liberal treatment. The pay of a clerk, for instance, is about \$43 a month; but on New Year's day he gets a present of about \$54 besides; and each clerk who can show an increase in his bank account of not less than about \$2.70 per month gets about \$1.35 more deposited to his credit in the bank. In the same manner each driver or other working man who can show a monthly increase of about 54 cents in his bank account gets about 54 cents more deposited to his credit in the bank. This money remains at compound inter-

*The unit of Danish money is the crown (krone), which contains 100 öre. One dollar is at present worth 3 crowns and 65 öre, and one cent is consequently equal to 3.65 öre.

est for a certain number of years, and by the time it becomes available it amounts to a substantial sum, which may help the owner to a home or enable him to open a business. The regular wages of a driver is from about 70 to 80 cents a day, but in addition to this he gets a commission on the milk sold of one-half öre for each Danish pound, the commission being the same for both sweet and skim milk, and at the end of the year he gets a commission of 1 öre for each pound of butter he has taken orders for during the year. By these means the company not only gets efficient servants but it retains them, and through its encouragements to work and to save it has a beneficial influence on all its employees. The credit for this model plan of supplying a large city with milk belongs to Grosserer Busk, of Copenhagen, more than to any other one man. He has been the leading spirit of the company from its inception and organization to the present day.

LARGE DAIRY FARMS.

ROSENFELDT FARM.

The first large dairy farm I had opportunity to visit is named Rosenfeldt, which is situated near the city of Vordingborg. It is the property of a Danish nobleman, Kammerherre Oxholm, who lives on the place. The farm contains 1,300 acres. The actual number of cows on the place was 276, which number was, however, to be increased to upwards of 300 by the addition of heifers which were soon to come in. Of the above number of cows 223 were in milk at the time of my visit, and they produced, on an average, 3,747 pounds of milk per day. This gives but an average of 17 pounds per day per cow, or about 2 gallons. If this seems a small output it should be remembered that it was in midwinter, when many of them were about to go dry, and that the native Danish dairy cow is but a small animal. The average weight would not much exceed 900 pounds per head. When these things are taken into consideration the milk yield was not small. These cattle were fed as follows: The first feed was given them at 4 o'clock in the morning and consisted of oat straw or barley straw. They got a liberal amount, and what was left was used for bedding. At 7 a. m. they were fed their grain, which averaged about 7 pounds per head per day, divided into two feeds, and consisted of 3 pounds barley and oats mixed and crushed, 2 pounds oil cake, usually half rapeseed cake and half palm cake or sunflower cake (of rapeseed cake they never fed more than $1\frac{1}{2}$ pounds), and 2 pounds bran. At 8:30 a. m. they got 20 pounds sugar-beet refuse each. The beets are grown on the farm and delivered to a neighboring sugar factory, but the refuse pulp is hauled back for feed. Or if the pulp is missing mangels are fed instead. Next they are watered in the stable, the water being turned right into the manglers, and after this they get 10 pounds each of hay from the meadow. The hay is of mixed grasses, containing also some clover. This completes the feeding for

the forenoon. At 1 p. m. the feeding begins again with the same feeds in the same quantities, beginning first with the grain, then roots, water, hay, and straw, keeping them busy eating all the afternoon, the straw being fed at 7 p. m., and this time wheat straw.

The milking begins at 4 o'clock in the morning and at 4 o'clock in the afternoon. It is all done by women, each of whom milks 20 cows, and they do it in from two to two and one-half hours. The churning temperature is 55° F., and butter comes in about thirty minutes.

The particular ferment which was used in this dairy received the following treatment: It is sold in bottles holding about a pint, all of which is used at one time. It is not added directly to the cream, but is first propagated in skim-milk. For this purpose the milk from a fresh cow should, if possible, be selected. The milk is set in ice water for twelve hours and then skimmed by hand. It is next sterilized by being heated to 180° F., at which temperature it should be kept for two hours. It is then cooled to 82° F. and the bottle of ferment is added, and this temperature should, as far as practicable, be maintained during the next twenty or twenty-four hours while the ferment is growing, which takes about that time. At the close of this process another batch of skim milk is sterilized as before. It is next cooled to 50° F., then again warmed to 82° F., and 10 per cent of its weight is added to it from the ferment made the previous day. This stands again another twenty-four hours at the same temperature as nearly as may be, and then it is ready to be added to the cream, for which purpose the cream should be at 70° F.

A herdsman styled "feed-master" has charge of the feeding. The milk is, of course, weighed as fast it arrives at the dairy, but twice a month there is a "trial milking," at which the milk is weighed from each cow, which enables them to get an approximately correct idea of the yield of each cow. The cows do not get out of the barn all winter. When tied up in the fall they remain there till they are put in pasture the following spring, which usually occurs the latter part of May. This, I find, is the practice on nearly all dairy farms.

The morning milk is run through the separator as fast as it arrives in the dairy from the barn, and the evening milk stands in the vat and is separated also in the morning.

The cream runs from the separator into the "pasteurizing" or sterilizing apparatus, where it is heated to 167° F., after which it is at once cooled on the cooling apparatus to 44° F. This heating and cooling is completed by about half past 7 in the morning, and from that hour until 10 a. m. it stands in ice water. It is then heated again, but this time only to 70° F., at which temperature the prepared cream ferment is added, and it now stands for about twenty hours, or until 6 a. m. the next morning, while the ferment does its work, and then it is churned. The amount of ferment added to the cream will in a measure depend upon the season, the cows, and other conditions. In the dairy to which

this refers it was found that of this impregnated milk 4 to 5 per cent of the weight of the cream should be added at this season to have the proper effect. The ferment is perpetuated in sterilized skim milk, which is prepared fresh every day, and what is made one day is used the next day both to ferment the cream and to start a new lot in fresh skim milk. On Mr. Oxholm's dairy farm it is found necessary to get a fresh lot of ferment from the laboratory about once in six weeks.

I have briefly described the process followed on this farm because the butter made there stands in high repute. It frequently takes prizes at the national butter exhibits, and I was told that it brought usually about \$1.62 per 100 pounds above the top market quotation. It is all exported to England. Nearly all the work in this dairy is done by women, and the chief dairymaid was certainly a competent person. Most of the skim milk was made into cheese of good quality. It is possible to make good cheese from skim milk, but the success lies in the knowing how, and I believe the time is coming when good skim-milk cheese will find a market in America.

At Rosenfeldt it required at this season 29 pounds of milk to make a pound of butter. The cream loses some of its butter by being sterilized as it was here.

About 1,000 pounds of skim milk was made into cheese daily, and the remaining skim milk was sterilized and fed to the calves and pigs. The cheese milk was warmed to 70° F. When it reached this temperature 10 per cent of fresh buttermilk was added—that is, 100 pounds to the 1,000 pounds of milk—and immediately afterwards rennet of a given strength was added. In this case it required seventeen one-hundredths of a pound of rennet for the amount of milk used. After the rennet had been stirred in, the milk was allowed to stand perfectly still until it had coagulated, which happened, usually, in about thirty minutes. The chief dairymaid informed me that if it coagulated in less than twenty minutes the cheese would be tough, and if it took over forty minutes in winter, the milk got too cool. The time when the desired degree of coagulation was reached was determined by inserting the finger and noticing how readily the cheese matter would break when the finger was gently lifted up through it from below. A certain brittleness was a sign that the process had proceeded far enough. The curd was then cut both ways with wire cutters and allowed to stand five minutes undisturbed, but at the end of this time it was stirred gently and continuously from twenty to thirty minutes. This stirring separated the curd from the whey. The whey was then drawn off and the curd was worked with the hands and pressed in the bottom of the cheese vat until all the whey that could be separated by this process was removed.

Four per cent of salt was next added to the curd and thoroughly mixed through it with the hands. The cheese cups were then filled and the cheeses were put under light pressure for twenty hours, being turned

three times during that period. On removal from the press they were put into a large tub of strong brine, so strong that the cheese would swim on the surface, and allowed to remain there from twelve to fourteen hours. On removal from the brine they were placed upon shelves in the cheese room, where a temperature is maintained of from 56° to 60° F. They remained there fourteen days, during which time they were daily turned and wiped on both sides with a cloth. After two weeks of this treatment they were transferred to another room where the temperature was kept lower than in the cheese room, and there kept until sold. During the first few weeks in this room they were washed every other day in strong brine, the object being to make the crust soft and thin. They were usually sold when about three months old and brought in the home market 19 öre per Danish pound, which is equal to about 5 cents per pound avoirdupois.

All the dairy work was in the direct charge of the chief dairymaid, who had half a dozen assistants, most of whom were pupils. The farm was managed by a superintendent, a scientifically educated gentleman and a graduate from the Royal Agricultural School of Copenhagen. He had several assistants. As stated, the farm consisted of about 1,300 acres, and it required 18 teams (36 horses) and 8 yoke of oxen to work it. The rotation observed at that time was as follows: First year, fallow, this being manured for the next year's crop; second year, rye or wheat; third, barley; fourth, sugar beets; fifth, barley; sixth, oats; seventh and eighth, clover and grass. But the superintendent informed me that it was contemplated to change the rotation to this: First year, rye or wheat; second year, one-third in potatoes, one-third in beans, and one-third in peas; third year, barley; fourth year, sugar beets; fifth, barley; sixth, oats; seventh and eighth, clover and grass. All of the land is fall-plowed and the manure is applied for the wheat and rye. Occasionally, also, artificial manure for the sugar beets.

On all of these large farms we find young men who are there to learn the business of farming. They may remain one or two years, according to contract, and some of them receive a small wage when they consent to eat at the tables with the hired men and in other respects "hoe their row" alongside the hired men. Others are there without any pay, and still others pay for the privilege of being there.

On this farm there were two classes of farm pupils, one class receiving 100 crowns a year in wages (about \$27) and the other class receiving no pay. All were required to work alike, however, and they were expected to work as steadily and hard as was required of the hired men, the only difference in their privileges being that they got their meals in a separate room. The hired men who worked on the farm received 200 crowns a year (\$54) and their board, and day laborers received from 36 to 37 cents per day, boarding themselves.

This farm also belongs to Kammerherre Oxholm, the owner of Rosenfeldt, already described, but it was tenanted by Mr. Stolpe, who had rented the farm for a series of years. The farm is some 700 acres in extent and was worked on a system of mixed husbandry, with special attention to dairying. At the time of my visit there were 260 cows on the farm, 50 of which were dry. An average of 3,000 pounds of milk per day was obtained from the 210 cows giving milk, and in addition to this 1,000 pounds per day were bought from neighboring farmers. The total amount of milk was, therefore, 4,000 pounds per day. The dairy work was in charge of a man, but the milking, cleaning of utensils, etc., was done by women. The feeding of the cattle was in charge of a so-called feed-master, who is also the cooper and makes the butter barrels. The cows were fed as follows: The first feed was given them at 4 a. m., and consisted of either oat straw or barley straw. The milking was done while this was being eaten. At 7 they were watered, after which they received a small feed of chaff. When this was eaten they got their grain, consisting of 1 pound of bran, 3 pounds of barley and oats ground together, and 1 pound of rape-seed cake. Half an hour later they each got 10 pounds of mangels and next a feed of hay. This completed the feeding for the forenoon. At 1 p. m. they were again watered and then followed in succession feeds of chaff, grain (the same as above), mangels, hay, and straw, the last feed being given about 6 in the evening. Milking was done about twelve hours apart, beginning at 4 in the morning and again at 4 o'clock in the evening. All the cattle remained in the barn during the entire winter, the water also being given them in the mangers. The cattle were of the red Danish dairy breed, with some crosses of the Angler breed. The evening milk was put in tall, tin milk cans, which were set in cold water over night. In the morning these were skimmed by hand and the milk, which had thus stood only twelve hours, was run through a separator, together with the morning's milk. The milk ran through a forewarmer, a machine already described, which raised it to 95° F., before it ran into the separator. The cream, as it came from the separator, ran into large milk cans which were at once immersed in ice water and cooled under constant stirring to about 35° F., and here it remained until it was again warmed for the reception of the ferment and set to sour in the cream barrels. They occasionally used artificial cream ferments and occasionally they made their own ferment from half-skimmed milk. The method followed on this place for the production of the latter was as follows: The evening milk from a nearly fresh cow was set by itself in ice water over night and in the morning was skimmed. The skim milk was warmed to 170° F., and then cooled to between 72° and 75° F., at which temperature it remained for twenty-four hours, when it was found to be sour. Of this sour milk 5 per cent of the weight of the

cream was added to the cream which had been separated in the morning and cooled off in ice water, as already stated. The cream was warmed to 70° F., before the sour milk was added, and it was, as far as possible, kept at this temperature until 6 the following morning, being gently stirred two or three times in the meantime.

During the winter the churning temperature was at 62° F., and the cream rose to 66° F. during the process of churning. In the summer, I was informed, they churned at 50° F., or a little above, according to the weather, and butter always came in from thirty to thirty-five minutes.

The crops on the farm consisted chiefly of barley, oats, rye, and a little wheat, and besides these, mangels for the cattle, some potatoes, grasses and clover. Of the grains only so much was sold as could be spared from the amount necessary to keep the live stock. The tenant, Mr. Stolpe, was an able farmer, and in spite of the fact that the rent of the farm came to some \$1,890 per year, he managed to pay all the expenses and still put something in the bank, the dairy being the main source of income.

THUREBYLILLE FARM.

This farm can also be classed among the large estates. It contains an area of a little over 700 acres, of which some 60 acres are in permanent meadow, and the rest under culture. The farm was owned by a landlord who had large estates in that part of the country, but it was worked by a company who used it as a stock farm largely, their objects being not only to pay expenses, but also to carry out certain experiments in breeding, in order to improve the breed of dairy cattle. Superintendent Tuxon, the able manager of the place, was a man of established reputation as a farm manager.

While they also had a dairy there, it was not the chief feature, but was simply coördinate with breeding of stock and the production of grain crops. They kept 150 head of cows on the place. These remained tied in the stable all winter. I did not see this herd, for the reason that there was a "foot-and-mouth-disease" scare in that part of the country and no stranger was admitted to the barn; but Superintendent Tuxon informed me that the cattle were all of the red Danish breed and that they were all superior animals. Their management was of interest because it varied somewhat from the common custom and may be said to stand out as the best example of the management of dairy cattle to be found in the country. The cows were classified in the barn as follows: All those which were in full flow of milk; all those which had passed the period of full flow but still gave milk; all dry cows; and, lastly, all barren cows, each class standing by itself in a different part of the same barn. The feeding of these varied, and this was the main reason for their classification. Cows in full flow of milk got their first feed at 4 o'clock in the morning, consisting of 6 pounds of hay,

and they were milked while eating this, between 4 and 6 a. m. At 6.30 a. m. each cow received $4\frac{1}{2}$ pounds of grain, consisting of $1\frac{1}{2}$ pounds of oil-meal (which was made up of one-half pound rape cake, one-half pound sunflower cake, and one-half pound palm cake), 2 pounds barley and oats mixed and ground together, and 1 pound bran. Immediately after this, each cow was given 15 pounds of whole mangels, and next they got a feed of barley straw.

Water stood before them at all times, in a little basin between each two cows, so that both drank out of the same basin. By a self-regulating valve in the supply pipe the water stood at the same height in these basins at all times. This very handy arrangement cost twelve crowns, or a trifle more than \$3 per head to put up. At 1 p. m. the afternoon feeding began, which was simply a repetition of that of the forenoon.

All other cows in the barn, not in full milk, got hay, straw, and mangels as these, but they were fed different amounts of grain, according to their condition. The strictest attention was paid to cleanliness. The barn was cleaned and swept twice daily, and all the cattle were bedded twice daily. Superintendent Tuxon believed that not only the barn should be kept clean, but that it paid to keep the skins of the animals scrupulously clean. To this end he employed a man who spent his entire time currying the cattle; he went over the entire herd with currycomb and brush twice daily. One man did all of the cleaning of the stable, and another curried the cattle, while a third attended to the feeding. The temperature of the barn was kept, as nearly as possible, at 60° F. for the cows and 55° F. for the calves. No artificial heating apparatus was used, but the barn was a substantial stone structure with perfect ventilation and provision against drafts, so that it was possible to maintain this temperature even in very cold weather. None of the cows were let out of their stalls during the entire winter. The summer management was equally exacting. The cattle were put on grass about the 15th of May and remained out of doors until about the 10th of October. During the greater part of this time they were tethered in the field, each cow being secured to a stick driven in the ground, and allowed the freedom afforded by a 20-foot rope. The whole herd was thus staked out in the pasture, beginning on one side and gradually moving over to the other side. This is, doubtless, the most economical way of utilizing the pasture. Each cow was given some 3 or 4 feet of fresh pasture at each change; the grass was thus eaten up clean, and nothing was wasted by being tramped down or dirtied by the herd. This method of pasturing is in very common use on the smaller farms and also on many of the larger ones, as in this instance. The entire herd was changed five times a day at equal intervals, all the work being done by one man. The watering was attended to by another man, who, with a horse and cart, hauled the water to tubs placed between each two cows. These tubs were moved forward

once in three or four days, as occasion required. All the cows giving milk were blanketed with light cotton blankets during the summer to keep the flies off, and, in addition to the pasture, they were fed a little grain daily, for the most part bran, and not to exceed 3 pounds per cow per day.

The management of the calves is also worthy of note. As soon as the calf is dropped, it is put in a small pen by itself, and within a couple of days it is injected with tuberculine to test whether or not it is affected with tuberculosis. If there is a reaction from this injection, shown by a rising temperature, then it is slaughtered at once, as this is a sure sign that it is affected; but if there is no reaction, it is spared. Then the healthy calves are put together by twos until they are 2 months old. Then four are put together in the same pen, and when the weather begins to get milder in spring they have access to a little open run in the yard. In May, when the cows are let out, all the calves are again injected with tuberculine to learn whether any of them have been infected during the winter. All which show a rise of temperature by this test are killed at once, and those which are healthy are allowed to run together without restriction as to number.

The object is to raise a herd which shall be entirely free from tuberculosis. It is admitted that at present a large percentage of the cattle in the country are affected by this disease. It is impracticable to kill all of the affected cows at once, as the loss would be too great, but by this method of weeding out infected calves the country will eventually be clear of this curse, and the object of the company, under whose auspices these experiments are carried out, is to ascertain what means can best be adopted so as to be at once effective and attended with the least loss. As to the value of tuberculine, Prof. Koch's great discovery, I was assured that in no instance had the slightest sign of the disease been found in animals which did not show a rise of temperature as a result of the injection, and, on the other hand, the germs of disease had, in every instance, been found in animals where this rise in temperature took place.

During the first summer the calves run together in a pasture to themselves. In the fall, when they are taken in, they are put, fifteen together, in a large pen and allowed to go loose. The following summer they are tethered in the same manner as the cows. The feeding of the calves is done with equal care and system. Each calf gets 300 pounds of whole milk and 2,000 pounds of skim milk up to the age of 5 months, and after that age they get no milk. It is divided about as follows: Until three weeks old all are fed the whole milk, the quantity being proportioned to the age of the calf. At 3 weeks old a little skim milk is added to the whole milk and the quantity of skim milk is then gradually increased during the next two or three weeks until, at 6 weeks old, the whole milk is entirely withdrawn. The maximum amount which is allowed in one day is 16 pounds of whole milk

or 20 pounds of skim milk. All the milk is boiled and then cooled to a temperature at which the calves can drink it.

The grain feed begins at 2 months of age. They then get a small quantity of a mixture consisting of equal parts of bran and linseed meal, and this is gradually increased up to $1\frac{1}{2}$ to 2 pounds per day, each, and in addition to this they always have hay before them. When the skim milk is withdrawn they are given mangels instead until they are put on pasture, and during the entire summer, while on pasture, each gets $1\frac{1}{2}$ to 2 pounds of grain daily. During the following winter each gets 40 pounds of mangels, 10 pounds of hay, and 2 pounds of grain (bran and linseed cake) daily.

The heifers are bred when 15 months old and hence drop their first calves at 2 years old. During the second summer they are together as stated, but without any grain. The calves are dropped from September to February. The following is the average weight of the cattle at the ages given: Calves average the first of May about 330 pounds; the first of November, about 525 pounds; at $1\frac{1}{2}$ years, about 700 pounds; at 2 years, about 825 pounds, and at 3 years, about 924 pounds. The heifers get 4 pounds of grain daily, in the fall, from the time they are put in the barn until they calve, and after calving they are treated in the same manner as cows. All cows in the herd which are not in calf are tried by a teaser every day, and if they show signs of heat, are bred to one of the fine bulls. The herd remains tied on pasture until about the middle of September, when they are turned loose on the stubble fields, these having been cleared of grain by that time.

At the time of my visit, in the beginning of February, the cows gave about 2,200 pounds of milk per day. Of this about 100 pounds was required for the young calves and the rest was set and skimmed. In this dairy no separator was used. It was run on the old plan of setting the milk in ice water and in the flat iron pans already described. The evening milk was set in the deep milk cans in ice water and the morning milk in the shallow iron pans. The milk stood from twenty-four to thirty-six hours before it was skimmed and then it was skimmed twice. The first skimming took place in the morning, when the morning milk had stood twenty-four hours and the evening milk twelve hours, and the second skimming in the evening when the evening milk had stood twenty-four hours and the morning milk thirty-six hours. In summer the iron pans were not used, all the milk being set in ice water. The cream was sterilized, not by means of a sterilizing apparatus, but by being heated to 170° F. in hot water. The water stood in a vat and was heated by steam formed in a little boiler set up for the purpose of providing hot water and steam to aid in cleaning the utensils, but not for the production of power. The cream, which had been put in deep cans, was heated by inserting the cans in this vat of hot water, the contents of each can being gently agitated all the while. When the thermometer indicated that the desired temperature was

consisted of a mixture of oil cake, bran, and barley and oats ground together. The quantity given each varied with the amount of milk she produced, but the feed was not excessively heavy, usually from 8 to 10 pounds of this mixture per day, in addition to which each cow would get 40 pounds of roots, 4 pounds of hay, and 8 pounds of straw. During the summer the cows were, for the most part, fed in the stable also, but were tethered on good pasture an average of two hours daily, and in addition each cow received about 4 pounds of grain daily.

I was interested in this very intensive system of agriculture and procured detailed accounts of receipts and expenditures. During the year 1892 the five head of cattle mentioned consumed 10,788 pounds of grain feed of the mixture above mentioned, valued at 608 crowns (\$166), and they also consumed roots and hay valued at 222 crowns (\$64). Total expense for feed, \$230, all of which, except the oil cake, was produced upon the place. The cows gave in return 30,438 pounds avoirdupois of milk, which, at the price received for milk at the coöperative dairy, was worth 1,073 crowns (\$294). This left but \$64 profit, but he placed a very high estimate on the feed, and the milk was valued at only factory prices. As a matter of fact, more was made from it by making it into butter and cheese at home, and the sale of a heifer brought 165 crowns (\$45). The swine ate 8,845 pounds grain, together with the whey and skim milk not otherwise used, and offal from the garden, on which he put a total value of 745 crowns (\$204), which seems a high valuation. The receipts were 902 crowns (\$247), from seven fat swine and twenty-one sucking pigs, but not including two or three head slaughtered for home consumption. I did not receive details of the fruit, vegetables, and seed sold, which must have been no inconsiderable item. These articles would have brought still better prices if the place had been located near the city, where they could have been sold to the best advantage. But, as it is, it is a fine example of the possibilities of a small place when properly attended to.

FARM OF HANS HANSEN.

I next visited another farmer in the same neighborhood, Hans Hansen, of Söllinge. He owns a farm of 93 acres and he had, at the time of my visit, 32 cows, 16 heifers, and 3 bulls. His cattle were of the best strain of the red Danish dairy cattle. He was, in fact, a breeder of fine dairy stock as well as a farmer. Several of his cows gave between 50 and 60 pounds of milk daily, and he got in the neighborhood of \$100 apiece for promising heifers. The average milk yield of his cows had been up to 8,800 pounds per cow, young and old, yearly; but during the last two years his herd had been troubled with abortion, which had somewhat reduced the milk yield. Still, during the year 1892, his 32 cows produced 226,317 pounds of milk, avoirdupois, which was sold to the coöperative creamery, besides what was used in the household, concerning which I did not get details. This brings the

average to 7,072 pounds per cow for the milk sold. His cattle are fed in the following manner: During the winter, first feed was given at 6:30 a. m., and consisted of 6 pounds of hay, and a little later three-fourths of a bushel of mangels. He used oil cake to a considerable extent, each cow getting about 6 pounds per day when in full flow, which was divided into two feeds, each feed being mixed with an equal weight of ground oats. His oil cake consists of equal parts of cotton-seed cake and sunflower cake, rape-seed cake and hemp-seed cake. After 3 pounds of this oil cake and 3 pounds of oats had been eaten the cows were watered, and then followed a feed of barley or oat straw, which finished the feeding for the forenoon. The afternoon feeding began at 3:30, this time with the roots, then grain, as above, water, and straw for the night, no hay being given in the afternoon. The cattle remained in the barn all winter without being let out once; the manger was built water-tight and the water turned into it twice a day, and what was not drunk was again drained off.

His barns were models of solidity and convenience. They were built of brick, with floors of squared stone and stalls and all auxiliaries of the most substantial nature. The drainage of the stables was well nigh perfect. Nothing was allowed to go to waste. The urine was collected in large cisterns, from which it was pumped out and hauled to the grass lands during the spring and summer, and the solid manure was kept under shelter. In summer the whole herd was tethered in the pasture, or stall-fed with soiling crops if the pasture was at all short. He practiced a seven-year rotation, as follows: First year, oats, half of which is sown to grass; second year, this half remains in grass and the other half is sown in soiling crops, which is either a mixture of vetches and oats or field peas and oats; third year, it is in rye; fourth year, three-fourths is in roots and one-fourth in barley; fifth year, oats sown with clover and grass seed; sixth year, meadow, and seventh year, pasture, which ends the rotation, the pasture being again broken up for oats. The manure is applied chiefly to the grass land and to the roots. The owner is now past middle age, but still active and energetic. By careful attention to his farm he has accumulated a fortune which enables him to present each of his several children with a comfortable farm, while he and his wife will live in comfort during their coming old age.

FARM OF CHRISTIAN RASMUSSEN.

I next visited several small farms on the island of Langeland, some of which I shall describe. In the village of Clausebølle I had a talk with a farmer named Christian Rasmussen. He owns 32 acres of land, on which he kept two horses, nine cows, several head of young cattle, besides half a dozen hogs, and a lot of poultry. His cows were of a good ordinary quality, but made no pretensions to be pure-bred stock. The nine cows averaged 6,600 pounds avoirdupois of milk per year.

The products of his dairy netted him in 1892 about \$55 per cow, not counting the labor; this is very nearly equal to \$500 from the cows alone. He sold pigs for about \$54, and wheat for about \$200. This makes a total of nearly \$750 as the receipts from this little farm. He followed a six-year rotation: First year, fallow; second year, wheat; third year, barley; fourth year, oats which were sown to grass; fifth and sixth years, pasturage and hay. This rotation is not so well arranged as it might be. As is the case on all other successful small farms, nothing is allowed to go to waste. Every particle of manure is saved and applied to the land. The solid manure is for the most part put on the fallow ground, as this is to be sown in wheat. The liquid manure is applied to the pasture in the spring.

FARM OF RASMUS ANDERSEN.

Rasmus Andersen, in the hamlet of Tressebølle, is one of the foremost farmers in that region, who also gives much attention to dairying. His farm is not so heavily stocked as is the case on some others. He owns 107 acres and this he works with five large horses, and he keeps from 20 to 25 milch cows, besides young stock and swine. He sells the milk to a neighboring coöperative dairy, except what is used in the household. During 1892 he sold milk for 4,489 crowns (\$1,230) from 21 cows, being an average income of \$58.50 per cow.

The cattle were of the red Danish breed and were superior animals. During the winter they were cared for as follows: At 6 a. m. they got a feed of wheat straw, and the milking took place while they ate this. About 7 o'clock they were watered, and immediately afterward they had a feed of chaffed barley or oat straw, which was moistened and mixed with the grain feed. The grain consisted of one-half pound of rape-seed cake, one-half pound of sunflower cake, 1 pound of bran, and 2 pounds of mixed barley and oats ground together. This was the ordinary grain feed which they had twice a day, but extra heavy milkers received a little more. When this was eaten they had a feed of hay, all they would eat up clean, and this was followed by a feed of straw, which completed the feeding for the forenoon. In the afternoon the same routine was repeated of straw, water, grain feed, or chaff, hay and straw, the milking taking place at 6 p. m. The cattle remained in the barn all winter, not being let out once. They were watered in the manger, which was built of tiling and water-tight. In the summer the cattle were lariatied in the pasture and received no grain except when the pastures were short; but pains were taken to provide first-class clover pasture.

Mr. Andersen followed an eight-year rotation: First year, bare fallow, which was heavily manured and which received four plowings during the summer and was sown in wheat in the fall. I was struck with the heavy seeding which he practiced; he never sowed less than two bushels of wheat per acre and preferred broad casting to drilling;

second year, wheat; third year, barley, which was sown with clover and mixed grasses. In the fourth year this was pastured, and in the fifth year cut for hay and was then manured and plowed up in the fall; and the sixth year sown in soiling crops, consisting of oats and peas mixed, or oats and vetches. This was fed in the stable when the pastures were short. The ground was plowed as fast as cleared; and the seventh year it was sown in barley and a portion in carrots, which was followed the eighth year by oats.

Mr. Andersen was highly impressed with the value of carrots for both cattle and horses, and he was planting increasing areas in this crop and intended, as soon as practicable, to raise enough to give the cattle at least one feed daily all winter. He recommended especially a yellow variety called "Long Green Head." The cattle eat the tops, as well as the roots. He raised them in rows one and one-half feet apart.

FARM OF ANDERSEN BROS.

I next visited a farm near the village of Leibölle, owned by two brothers named Andersen, who worked it in company. Their farm consisted of 66 acres of land on which they kept three good horses, or sometimes four, sixteen cows, some six or eight head of young stock, besides some swine and a few sheep. Their cows were of the red Danish breed and were considered superior animals, several of them milking between 40 and 50 pounds each per day. Their milk was sold to a neighboring coöperative dairy at fixed prices. The receipts from these sixteen cows during the year 1891 were as follows, by months. I am able to give this as they kindly permitted me to look into their account books:

January, 265.96 crowns; February, 310.91 crowns; March, 398.84 crowns; April, 380.88 crowns; May, 346.38 crowns; June, 292.15 crowns; July, 273.64 crowns; August, 250.44 crowns; September, 239.00 crowns; October, 169.93 crowns; November, 226.99 crowns; December, 328.06 crowns; total, 3,483.20 crowns; to which should be added 864.88 crowns, as their pro rata share in the profits of the creamery for the year. Grand total, 4,348.08 crowns (\$1,191) as the receipts from sixteen cows in one year. The cows were fed as follows: At 6 a. m. a feed of straw, which they ate while the milking proceeded. Next a feed of moistened chaff made from barley or oat straw mixed with the grain feed. The grain feed consisted of 2 pounds of sunflower cake and 2 pounds of bran. When this was eaten they were watered and after their water they had a feed of hay. In the afternoon about 3 o'clock each cow got a feed of 50 pounds of roots, mangels, or carrots, while they lasted; at 4 p. m., again moistened chaff and grain. This time the grain consisted of 1 pound of rape-seed cake and 3 pounds of equal parts of barley and oats ground together, then they were watered. Next followed a feed of hay, and lastly, about 6 p. m., a feed of straw. The cattle stand in the stable all winter. In

summer they were tethered on good pasture until harvest, except for a period during the last of June and beginning of July, when they were again stabled and fed on soiling crops. After harvest they run loose in the stubble fields. They get 3 pounds of bran per head daily during the summer. All the manure produced upon the place was saved with great care. The urine from all the stock was collected in cisterns and applied to the grass lands in the spring. Their system of rotation was as follows: First year, fallow, which was plowed several times and manured, and in the fall sown to wheat. They seeded also very heavily, using seed wheat at the rate of $2\frac{1}{2}$ bushels per acre. The yield of wheat one year with another had for several years averaged 55 bushels to the acre. Second year, wheat; third year, barley, which was sown at the same rate and yielded about 50 bushels to the acre; fourth year, mangels and potatoes and a soiling crop consisting of oats and vetches grown together, the three occupying nearly equal areas; fifth year, oats, which were sown at the rate of 4 bushels to the acre and yielded, on an average, upwards of 80 bushels to the acre. The oats were sown with grass and clover. Sixth year, grass, used for pasture and hay; and seventh, grass, used for pasture and hay, which ended the rotation, the pasture being broken in the fall of the seventh year and followed by fallow. The two young men who owned and worked this farm had received more than an average education and were fine types of the best class of small farmers.

FARM OF P. NIELSEN.

On leaving the island I met a prominent breeder at an inn and had an interesting talk with him in regard to his business; but I did not see his place or any of his stock, it being too much out of my way to go there. His name was P. Nielsen, and he lived in the village of Torpe, Langeland. He informed me that he owned 69 acres of land, on which he kept 14 cows and about 6 head of young stock, the number he usually reared annually. His cows were of the red Danish breed, and several of the best ones gave each between 10,000 and 11,000 pounds of milk per year. All of his stock were recorded in the herd-book and he sold his heifers at high prices. He managed his cows somewhat differently from what is customary there, in that he fed them oftener. Each cow in full milk got 6 pounds of mixed barley and oats ground together, 2 pounds of bran, and 2 pounds of sunflower cake daily, this being divided into three feeds. The first feed was given at 5 a. m., consisting of straw; next they had one-third of the grain mentioned, then three-fourths of a bushel of roots, then a small feed of hay and again a feed of straw, and this course was repeated twice more during the day. Mr. Nielsen followed a seven-year rotation: First year, fallow, which was manured and sown to wheat in the fall; second year, wheat; third year, oats, laid out with clover and grass; fourth year, pasture; fifth year, hay; sixth year, half roots and half barley and oats

mixed, which is grown for feed; seventh year, barley. He stated that his yields were about as follows: Wheat, 50 bushels to the acre; oats, 70 to 75 bushels; barley, about 50 bushels. Mr. Nielsen was superintendent of one of the many "bull associations" which are common in the country and of which I have already written. His association was a stock company of farmers, who bought bulls of superior quality, to be used on the cattle in their herds. These bulls were boarded out at various places, always, however, with some member of the company. Mr. Nielsen's association owned seven such bulls. The service fee to members was 2 crowns, or about 55 cents, and to non-members it was about \$1.35.

ESKELUND DAIRY FARM.

This farm, on the island of Funen, was cultivated by a tenant farmer, who was absent at the time of my visit, and the following facts in regard to the place were obtained from the foreman: The farm is 240 acres in extent, soil of only fair average quality. They kept 12 work horses, 3 brood mares, 50 head of dairy cows, 2 stock bulls, a varying number of young cattle, which, however, amounted to as many during the year as there were cows. The cattle were all highly-bred, herdbook stock, and all the calves were saved. Besides this they had from 50 to 60 head of swine and the usual complement of poultry of all kinds. This herd is known all over the country, it being one of the most highly-improved herds of the red Danish cattle. It has been bred with care for about fifty years, and the herd has acquired a uniformity in color and build which is not always found in highly-bred stock. All the cattle were solid red and of an average weight of between 1,000 and 1,100 pounds. They were stabled in a fine brick barn, where they remained all winter, not being let out for water. Their feed during the winter season was as follows: at 4 a. m. they got a feed of barley straw, which they ate while the milking was in progress. At 6:30 they were watered, after which they got a feed of grain, consisting of 2 pounds of barley and oats mixed and ground, 1 pound of bran, one-half pound of palm-nut cake, one-half pound of rape cake, and one-half pound of sunflower cake. After this came a feed of roots. At 8 a. m. a small feed of hay was given and at 8:30 a. m. straw. At 11:30 a. m. they were again watered. The afternoon feeding began at 1:30 p. m. with a feed of straw and then the rest in the order as given above, with the exception of water. The management of the calves is of interest. Up to 2 weeks old they were fed on milk from their dams, each calf getting his own mother's milk, but about the tenth day they begin to mix in skim milk, the quantity being daily increased until in a few days the sweet milk is entirely supplanted, when they continue to get warm skim milk three times daily. But no one calf is ever allowed more than 24 pounds in a day, and that much only when about 2 months old. Soon after the skim-milk feeding begins a little linseed-oil meal is mixed with it and later

ground oats, with hay and roots constantly before them. When between 5 and 6 months old the skim milk is gradually replaced with whey, which they get for a few weeks. The calves are pastured in summer and receive, in addition, some oil meal and ground barley and oats mixed. The heifers are bred to calve at 2 years old, and they calve at all seasons in order to have a moderately regular supply of milk. It is no small amount of work to feed some 30 or 40 head of calves in the above manner, each one having his own special "bill of fare." I was told that all the young stock sold readily at high prices. Bulls often brought 700 crowns (\$190) apiece. The tenant farmer, Mr. R. Christensen, is one of the most enlightened men in the neighborhood. He exhibited his cattle at all the leading shows and always carried off prizes. In 1878 he was awarded a silver medal at the Paris Exposition for a herd he had sent there. The cropping of the farm was an eight-year rotation, beginning the first year with fallow, which was manured. It was followed the second year with wheat and rye, and the third year, barley. The fourth year it was again manured for soil-ing crops, consisting of oats and vetches mixed, or oats and peas and mangels; fifth year, mixed grain, barley and oats used for feed, and with this laid out to clover and grass; sixth year, hay; seventh, pasture, the cattle being tethered in the field; and eighth year, oats, which completed the rotation.

RAVNDROP VÆNZGE FARM.

In the same neighborhood I visited another farm owned by Mr. P. Nielsen. This farm consisted of 84 acres of only medium quality soil, it being rather light, but it sustained 4 good horses, 40 head of cattle of all ages, and a small herd of swine. The cattle were all of the red Danish breed, purely bred and recorded stock, and the herd contained some of the best individuals of that breed. It was in many respects a model place. The barn was fireproof, built of brick with iron posts and well lighted and ventilated, and the floor was made of cement, perfect drainage being provided. At the time of my visit he had 20 cows, 7 yearling heifers, 3 bulls, and 12 calves. Mr. Nielsen practiced in-and-in breeding closely and so far with the best results. The cattle were of the usual size of that breed, between 1,000 and 1,100 pounds avoirdupois in weight. They were fed as follows: The first feed was given at 7 a. m., which was a grain feed and consisted of one-half pound of rape-seed cake, one-half pound of palm-nut cake, 1 pound of sunflower cake, one-half pound of hemp-seed cake, three-fourths of a pound of cotton-seed cake, one-half pound of bran, and 1 pound of ground barley and oats. This was for the best cows, however, those not in full milk not getting so much. When this was eaten they had a feed of straw; third, about 25 pounds of mangels per head; fourth, a small feed of hay; fifth, water, and sixth, a feed of straw, which finished the feeding for the forenoon. At 3 p. m. the afternoon feed-

ing began exactly in the same order as above, the last feed being straw, which was given at 5 p. m. They are watered in the stable, which is customary everywhere, and are not turned out all winter. They are milked three times a day both winter and summer. The first milking begins at 6 a. m. in the winter and at 4 a. m. in the summer. During the summer the cows which are in milk are let out two hours each day on good pasture; but for the rest of the time they are in barns where they are fed equal parts of palm-nut cake, sunflower cake, and bran to the amount of 4 or 5 pounds a day in two feeds. Besides this they get green clover, or green oats and vetches grown together, and some little hay. All the grain is fed dry. Heifers and cows not in milk are tethered in the pasture most of the time. In the beginning of the '60's Mr. Nielsen's father procured a couple of fine heifers, which became the foundation of this very interesting herd, and during the last fifteen years the herd has been bred in-and-in closely.

A few figures in regard to the feed and produce of this herd may be of interest.

Average consumption of feed and yield of milk per cow, including heifers and barren cows.

Year.	Grain and oil cake.	Roots.	Hay.	Green fodder.	Yield of milk.
	Pounds.	Pounds.	Pounds.	Pounds.	Pounds.
1883	3,033	4,620			7,870
1884	2,910	3,938			7,694
1885	2,904	4,103	607	12,914	7,887
1886	2,910	5,170	968	11,704	8,083
1887	2,922	11,110	484	12,056	8,082
1888	3,148	11,770	404	11,528	8,516
1889	2,447	10,560	610	17,875	8,373
1890	3,195	10,569	830	12,205	9,253
1891	2,663	9,534	1,479	11,616	8,322
1892	2,787	12,079	1,513	12,848	8,795

Yields of some of the individual cows in the herd.—"Tolly" gave as a two-year old, 8,195 pounds of milk avoirdupois; at 3 years, 9,473 pounds; at 4 years, 9,744 pounds; at 5 years, 11,327 pounds; at 6 years, 10,080 pounds; at 7 years, 11,982 pounds; at 8 years, 13,043 pounds; at 9 years, 13,171 pounds. The latter figure is her yield in 1892. "Habele" gave, as six-year old, in 1892, 12,056 pounds of milk. "Anmaette" at 9 years old in 1892, 12,219 pounds. "Purtse" at 8 years old in 1892, 11,044 pounds. These are some of the very best yields of the breed.

Mr. Nielsen practiced a six year rotation, as follows: First year, rye; second year, barley, for which he uses a light dressing of Chile saltpeter; third year, mangels; fourth year, oats, which is laid out with clover and grass; fifth year, hay; and sixth year, pasture until July, when it is manured and broken for rye, being plowed three times before seeding in the latter part of September. All the manure produced upon the place is carefully saved.

HOLEV FARM.

In the village of Holev, some miles from the city of Odense, is a farm belonging to Jens Hansen's widow, which is one of the many interesting smaller farms in the neighborhood. It is superintended by her son, a young man who has the advantage of a good education, but the credit for the present condition belongs to the young man's father, who died only two years ago. The farm contains 125 acres, 19 of which are taken up by building sites, garden, orchard, farmyard, and a large wood lot. The remaining 106 acres are under culture. On this they had, at the time of my visit, 7 work horses, 2 colts, 26 cows, 8 heifers, 6 bulls, and 12 calves, besides 19 head of hogs, several of which were brood sows. The cattle were all of the red Danish breed and recorded in the herdbook. Jens Hansen had been a noted breeder ever since 1838, but the present herd has been bred since 1852, when he purchased a cow which proved to be of superior value and from which most of the herd has sprung, though some ten years later he procured three other excellent cows, whose progeny are in the herd. The young stock sells at good prices. A choice heifer, or bull, frequently brings as much as \$270. I saw a three-year-old bull there for which I was told they had been offered about \$378, but refused the offer. The cattle are fed in the following manner: The first feed consists of straw and is given at 5 a. m. when they are milked, and afterwards the stable is cleaned. Next, they are watered at 7:30 a. m. and immediately after they get a grain feed consisting of one-half pound of rape-seed cake, one-half pound of palm-nut cake, one-half pound of sunflower cake, one-half pound of cocoanut cake, 1½ pounds of mixed barley and oats ground, and 1 pound of bran. At 8:30 a. m. they get a small feed of hay. At 9 they get about 25 pounds of mangels and at 10 a feed of straw. The stable is then closed and kept as quiet as possible until 12, when they are again milked. After another season of rest the feeding begins again at 2:30 p. m. and consists of the same material in the same order, with the exception that they get no hay, but instead a feed of straw. In the evening they are milked at 7:30.

In summer the herd is let out some time during the first half of May, but is taken in at night, if the season is cold and rainy. They are tethered on the pasture until after harvest, when they are turned loose in the stubble field. During hot weather and when the flies are bad they are taken in during the day and let out at night, and in the fall again they are taken in at night and are out only in the daytime. If the grass gives out in the latter part of June, as is often the case, then they are put in the stable and fed on soiling crops until the pastures improve. During the entire summer each cow gets from 4 to 6 pounds of grain daily, half of which is oil cake and the other half barley and oats mixed. As in former cases, already mentioned, the calves receive special care. Each calf is kept in a pen by itself and fed on its mother's milk until 2 weeks old. The whole milk is then gradually supplanted

by skim milk, and in the course of eight to ten days they get nothing but skim milk. The quantity allowed them is also carefully graded. The first day they get but $1\frac{1}{2}$ pounds of milk in three feeds. When a week old a thrifty calf is allowed $1\frac{1}{2}$ pounds three times a day, and when 2 weeks old 4 pounds each time, three times daily. In addition to this, they get crushed oats and linseed cake, the latter stirred in the milk as soon as they will eat it, and a little cut roots and hay constantly kept before them. When a month old they get 8 pounds of skim milk at each feed, three times daily, the milk being warmed to the temperature of the body. They never get more milk than this at any age, but the grain is gradually increased to 2 pounds daily, besides what roots and hay they will eat. They get no water at all while they are fed milk. Fall calves, which have gone through this course of treatment during the winter, are put on pasture the following summer, but spring calves are kept in the barn all summer, and in addition to the above treatment get a little cut grass daily. The grain continues, however, all summer for those on pasture. The following winter the yearlings get 3 pounds grain daily each, and about 30 pounds of roots. The heifers are bred when 15 months old, and after they calve the grain is increased gradually, as they can take it, up to the normal feed for cows. The cows have a disposition to milk perpetually, but they are dried up for six weeks, during which time each gets 6 pounds grain daily and 40 pounds roots, if her dry season happens to be in the winter. Their service bulls were fed from 4 to 6 pounds of oats daily, but no oil cake or any other kind of grain; in addition to this they got 25 pounds of mangels and all the hay and straw they would eat.

The milk was creamed and churned at home. There was a convenient ice dairy in the basement of the dwelling house where the milk was set in the usual tall tin cans and skimmed by hand. There was no separator on the place. The following are the outputs of milk and butter for each month during the year 1892, in pounds avoirdupois. The milk yield does not include the sweet milk fed to the calves, nor the new milk from fresh cows:

Month.	Milk yield.	Used in household.	Milk creamed and churned.	Butter made.
	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>	<i>Pounds.</i>
January.....	14,510	440	14,070	507
February.....	14,617	440	14,177	528
March.....	18,018	440	17,578	698
April.....	20,904	440	20,464	782
May.....	19,644	440	19,204	737
June.....	19,504	440	19,064	667
July.....	17,360	440	16,920	602
August.....	13,129	440	12,689	471
September.....	10,511	440	10,071	387
October.....	11,089	440	10,649	427
November.....	12,042	440	11,602	448
December.....	10,945	440	10,505	389

I was kindly permitted to draw these figures from their account book. The processes followed in the butter-making were the same as those already repeatedly described. The butter sold for the same prices as were realized by the large dairies. Cheese was made of the skim milk, but only for home use, though a small surplus had been sold during the year to the value of about \$54.

The ground was cultivated in a seven-year rotation. First year, oats, for which the pasture had been broken the previous fall; second year, roots, chiefly mangels, but also some carrots and turnips, the first two being for the milch cows and the last for the young stock. This crop is manured; third, two-thirds of the field in barley and one-third sown in Italian rye grass and yellow clover; fourth, the two-thirds which was in barley was manured and sown with soiling crops, vetches, and oats mixed; fifth year, the one-third which was in grass during the third and fourth years of the rotation is broken and sown in barley, which is cut for hay in June, and the two-thirds which was in soiling crops lies fallow and is plowed two or three times, and the whole field sown in wheat or rye in the middle of September. Sixth, this rye field is fed off and half of it sown in red clover and grass and the remaining half sown with barley and oats mixed, which is laid out with grass; seventh year, all is in grass.

The milk yield, not of the best cows, but of the whole herd including heifers, barren cows, and those that aborted, has averaged the following amounts per head for the years mentioned, in pounds avoirdupois: In 1886, 7,453; in 1887, 8,525; in 1888, 8,074; in 1889, 6,921; in 1890, 7,067; in 1891, 7,619; in 1892, 8,145. This, of course, gives no indication of the yield of the best cows, which runs up to 10,000 and 11,000 pounds each.

To show the possibilities of such a dairy on a 100-acre farm I drew from their books the sales and prices realized during 1892:

Products sold.	Prices.
	<i>Crowns.</i>
7 young bulls	3,150
4 old cows	740
5 heifer calves	1,065
9 other calves	410
17 fat swine	1,339
5,738 pounds butter	5,049
Milk	24
Cheese	200
Total	11,977 (£3,282)

Cost of bran, grain, oil cake and all the feed bought for the herd 3,027 crowns (\$829). The rest of the feed was produced upon the place. The herd is exhibited in all the leading shows in Denmark and sometimes in foreign countries. In 1879 representatives from this herd took first premium in London, England. Since 1859 the herd has twice

taken sweepstakes, in competition with the whole country, and taken sixty-six other prizes, of which thirty-eight were first prizes.

HERMANS MINDE FARM.

This property is owned by a Mr. Hermansen, and is situated on the peninsula of Jutland, a few miles from the city of Fredericia. It is a beautiful place, with a large, rather imposing brick dwelling house, substantial brick barn, and supplied with all modern conveniences. The cow stable was especially large and airy, built of iron and brick, so as to be entirely fireproof, with a good floor, and well drained. The property consisted of 150 acres, which was worked with 6 horses, and there were at the time of my visit 36 head of dairy cows, 13 head of young stock, a few sheep, and some 30 swine. The cattle were treated in the following way: They were watered the first thing in the morning, at 5 a. m.; then they were given a feed of grain consisting of one-half pound of rape-seed cake, 2 pounds of mixed barley and oats, ground, and 2 pounds of bran per head; after this they got a feed of straw, then a small feed of hay, then a feed of straw again, when they rested until 1 p. m. At this time they were again watered and then given the same routine of feeds as in the forenoon. Some roots were raised, but seldom enough to last through the winter. No beeves were fattened except such cows as did not prove profitable for the dairy. The herd remained in the stable all winter, and they were also stabled every night during the summer, when they were fed soiling crops and hay, the object being to save the manure. The cattle were of a rather mixed character, none of them pure bred, though most of them belonged to the red dairy breed. The average milk yield per cow approached 6,000 pounds avoirdupois. The dairy department was in charge of a grown daughter, who kindly gave me details concerning her management.

The dairy room was located in the basement, at one end of the dwelling house, and was very conveniently arranged. It was an ice dairy, a capacious ice house near by being filled every year. Instead of the cement basins to hold the ice water, large tubs were used. These have some advantages over the brick and cement basins. They are very much cheaper, in the first place, and they are more readily cleaned and can be moved to the most convenient point in the dairy. These tubs were a few inches taller than the milk cans and each would hold nine or ten cans (see Fig. 4). A deep, cool well supplied all the water wanted, of the purest kind. It was raised to a tank on top of the house by means of a pump worked by horse power and from this tank pipes supplied water wherever needed. At the time of my visit 28 cows were giving milk, but many of them were nearly dry. This number supplied 500 pounds of milk daily. As soon as it was received from the barn, and was strained and weighed, it was transferred to the cans, which were sunk in the ice basins, where it remained thirty-six hours; but the milk was skimmed three times during that time, at the expiration of

twelve hours, twenty-four hours, and thirty-six hours. The cream was kept in ice water until enough was collected for a churning; then it was warmed to a temperature of 70° to 74° F., when half a gallon of buttermilk from last churning was added. It then stood for twenty-four hours packed in a hay mattress, the object being to keep it as nearly as possible at about 60° F. The process of souring was watched in the meantime and if too rapid the temperature was reduced. She churned, at that time of year, at 54° F. The churn was of the pattern already described; in fact, I saw no other styles anywhere. She churned by horse power, and the butter always came in about thirty minutes. The butter was removed from the buttermilk with a sieve and worked by hand. It received three workings. At the first one, the buttermilk was pressed out. Soon after this 4 per cent of salt was added and worked in a little. It was then put in a cooling box and about an hour later it received a final working, when it was packed in butter barrels of the customary form. It required about 27 pounds of milk to make a pound of butter. In the fall, when many of the cows were about to go dry, the milk was more difficult to manipulate; the cream did not rise so readily, nor did it churn so well. She then set the milk in shallow iron pans, of the style already described, the pans being used also for the reason that they save ice. The ice supply usually runs short at that time of the year. She had not found it necessary to use pure cream cultures. The butter was first class and usually brought about \$1.08 per 100 pounds over the top quotation of butter by the exchange in Copenhagen.

All the skim milk which was not used in the household, or for pigs and calves, was made into cheese. Her process was as follows: The cheese vat was a round tub which could hold about 400 pounds. The milk was warmed to 86° F., when she added 12 per cent of buttermilk. Then she added four one-hundredths of a pound of rennet extract to 350 pounds of milk. It was then allowed to stand thirty minutes to coagulate, when the curd was stripped and the whole mass stirred for fifteen to twenty minutes until the whey became clear and the small grains of curd would break when pressed. The whey was then drawn off and the curd put at once in the cheese cup. Her practice differed at this point from most other cheese-makers in that she did not permit the curd to be worked before it was put under the press. This, she maintained, would make the cheese tough; nor should it be allowed to cool before it was put under the press. The pressure applied is very light at first, and in half an hour the cheese is taken out and turned and again placed in the press, this being repeated four times during the first day. The following morning it is taken out and weighed and put in strong brine, where it remains for two days. It is next placed on the shelves in the cheese room, where it is turned and wiped with a dry cloth every other day. She got 23 öre per Danish pound, for her skim-milk cheese, which is about equal to 6 cents per pound avoirdupois.

An eight-year rotation was followed on this farm. First year, oats, the ground being broken from grass the previous fall. The oats were sown very thick, at the rate of nearly 6 bushels to the acre, and the yield reached nearly 100 bushels per acre; second year, fallow and manured with some 14 to 16 tons of stable manure per acre in May or June, and the fallow was plowed five times during the summer; third year, wheat or rye, sown on the fallow the previous fall. About 3 bushels of seed wheat per acre were used and the usual yield was from 40 to 45 bushels per acre; fourth year, barley, the barley ground being manured after harvest before the fall plowing; fifth year, barley and oats mixed, this being grown for feed, and the land was laid out with clover and grass; sixth, pasture or hay; seventh year, pasture or hay; and eighth year, pasture or hay, the grassland being broken and manured late in the summer of the eighth year. The help on the farm consisted, first, of a herdsman, who tended the stock and did odd chores about the place; second, two men and a boy of some 17 years. These were kept the year round and got their board and lodging and the customary wages (about \$60 a year). In the house were kept three hired girls. The butter consumed in the household averaged 660 pounds avoirdupois annually, and about 6,000 pounds was yearly sold for export at an average price of nearly 27 cents a pound. Fat swine were sold to the value of about \$540 annually, besides what was made into bacon for home consumption. The sale of skim-milk cheese amounted to about \$162 yearly, and what grain was sold would balance the feed bought.

DALUM AGRICULTURAL SCHOOL.

In conclusion I will add a few notes from the farm of Dalum Agricultural School, situated near the city of Odense. This is a private school owned by J. Peterson, who was president and head teacher. The foundation of it is a small farm of 80 acres, in connection with which the proprietor has erected buildings and engaged teachers for the instruction, in agriculture, of about 100 pupils. I shall speak more fully of the school under another heading, and will at present note only what I learned concerning their farm practice. Owing to the absence of the proprietor, who is himself also professor of agriculture, and takes charge of the management of the farm, I could not obtain as detailed an account of the place as I desired. As stated, the farm consisted of 80 acres, on which were kept, at the time of my visit, 26 cows, 1 bull, and 3 heifers, all of the red Danish dairy breed, and superior individuals. These cattle were treated as follows: They were milked at 5 a. m.; at 7 a. m. they got a grain feed consisting of three-quarters of a pound of rape-seed cake, 1 pound of sunflower seed cake, three-quarters of a pound of cotton-seed cake, 1 pound of hemp-seed cake, and 1½ pounds of bran, and immediately after 25 pounds of sliced mangels. When this was eaten they were watered and they then got

4 pounds of hay, which completed the feeding for the forenoon. They were again milked at 12, and about 3 o'clock the above feeding was repeated, with the exception that they received straw instead of hay. They were milked the third time at 8 p. m. The average annual yield per cow, of all ages, reached 7,700 pounds avoirdupois. After the milk had been strained and weighed in the dairy the noon and evening milkings were put in ice water until the following morning, when it, together with the morning's milk, was run through a small separator, the milk being first warmed to 90° F. The cream was at once cooled off and kept in ice water until the ferment was added. They used the pure ferment produced by Mr. Quist, of Skanderborg. When enough for churning had been gathered, it was warmed to 66° F., and the ferment was added. At the time of my visit the churning temperature was 57° F. The dairy is not considered part of the school, except during three months of the summer, when there is a special dairy class in attendance. The rotation followed on the farm was as follows: First year, barley, which was laid out with clover and grass; second year, part of this was pastured and part was cut for hay, the cattle being tethered on the pasture; third year, oats; fourth year part of it was in soiling crops, which consisted of mixed barley and oats, oats and vetches, and oats and peas, and part was sown in buckwheat and yellow mustard, which were used as pasture. These were sown at different times, and what remained after pasturing was plowed under for green manure. This is termed a "cultivated fallow," to which manure is applied in the fall; fifth year, wheat or rye; sixth year, barley; and seventh year, mangels and sugar beets, which they use for feed. All the manure from the stables is saved with the greatest care. Drains from cow stable, pig-pens and horse stables led to a large cistern where all the liquid was collected, and the solid manure was kept under a shed. The liquid was partly applied to the grass land and partly sprinkled on the solid manure. A portion of the farm, comprising some 5 acres, was in permanent meadow and to this the liquid manure had been liberally applied for a long time, and it was found that when thus applied it, after a time, lost its beneficial influence unless lime and phosphoric acid were also added.

COÖPERATIVE CREAMERIES.

I have so far confined myself to the description of private dairies, large and small. I shall now consider the organization and work of the large number of coöperative creameries throughout the country. It is chiefly these that benefit the small farmers. They are patronized by men who, as a rule, keep but a limited number of cows, say from one to fifteen or twenty head, though occasionally the milk from much larger farms is also worked up in these creameries. It is from this class of creameries that the bulk of the export butter comes, and it is

really these that fix the standing of Danish butter in foreign countries. There are two classes of creameries, which are distinguished from each other only in ownership, but which are alike in methods of operation and all other characteristics, and they can therefore be treated together under the above heading. The first class is the coöperative creamery proper, which is owned in company by all those who deliver milk there. The second class is the kind so largely represented in America in which the creamery plant is owned by one man, or at most by a few individuals, who buy the milk from the farmers of the neighborhood. The former are called "Andels" creameries, which is, properly translated, coöperative creameries. The second class is called "Fælles" creameries, and the name denotes delivery of milk by several individuals to the same creamery. In the former class the producers of milk have a personal interest. Their profits depend upon the management of the institution. In the second class they have no direct interest—it is merely a place where they sell their milk at so much per hundred-weight, and the owner takes all the financial responsibility. The latter class of creameries has constantly decreased in number, while the former class has constantly increased. When it was found that coöperative creameries could be conducted without disagreement among those interested, and on an economical basis which would yield the best attainable returns, everybody wanted to join them. The Fælles creamery was doomed to go. None were willing to grant profits to the creamery owner if they could just as well share them. The creamery owners, on the other hand, became obliged to pay so much for their milk, if they wanted any, that a profit was practically impossible, and it has not unfrequently happened that when the farmers did not get the prices they thought they ought to have, they have built a coöperative creamery to which they have sent their milk and left the other creamery owner out in the cold.

I have nowhere been able to obtain definite statistics in regard to the number of coöperative creameries in the country, but I have seen various estimates placing them at from 1,000 to 1,500, and I am inclined to believe that the latter figure is very nearly correct. The number of Fælles creameries, on the other hand, does not probably exceed 400.

All these structures are alike in their essential points, and one traveling in the country soon learns to recognize them afar off. There are the two-story brick buildings with short wings for engine-houses, and the imposing brick chimneys, which are invariably present. They are usually located near the highways, at some central point of the district contributing milk, and the arrangement of detail, which I shall describe more fully hereafter, is essentially the same in all of them. They differ, however, in capacity from about 300 cows up to 1,500 or even more. The Fælles creamery has been in operation there for many years, but it is only during the last ten years that the coöperative

creameries have sprung into existence. The history of their beginning and later growth is exceedingly interesting.

ORIGIN AND GROWTH.

They had their origin in the desire on the part of the small farmer to make the most possible out of his dairy. He had the example of the larger farms before him, where the dairy had always been an important and well-paying branch. How would it be possible for him to get relatively as much out of his few cows as the large farmers got out of their cows? The latter found it economical to place the dairy in the hands of expert help who could make first-class butter, which would realize the top market price; but the wives of the small farmers were by no means expert dairywomen. Their butter could not compare in quality with that produced upon the larger farms, nor was there any hope of so improving their practice that any considerable number could be counted on to make first-class butter. The only way open was for the farmers in the district, who were all equally interested, to unite, build a creamery, and deliver their milk there for creaming and churning; and this was what they finally did. But it resulted in this through some intermediate steps. The first of these was taken during the winter of 1881-'82. A few farmers in a certain part of the peninsula, after consultation, conceived the idea of engaging an expert at a stated salary per year, who should go from farm to farm and give instruction in dairy methods, and act as joint adviser and agent for them all, which position was offered to a Mr. S. Andersen, an educated man in the neighborhood. He saw, however, the insuperable obstacles to this course. Even though each farmer might provide the necessary utensils and the proper accommodations for the dairy, still their wives and daughters, his prospective pupils, would not all be equally apt learners, and those who found that the enterprise did not bring the desired results would soon withdraw from the arrangement. So for a time it amounted to nothing. But Mr. Andersen made them the proposition that if they would furnish him with a proper creamery and allow him the necessary help he would receive and churn their milk under his personal supervision and for a stated yearly salary. After many meetings it was finally decided to adopt this plan. But it was found that a sufficient number of farmers to represent 400 cows could not be obtained, and Mr. Andersen refused to begin operations with a less number. Three hundred cows were subscribed at once, and there were one or two hundred more in the neighborhood, but their owners did not think well of this new and untried coöperative scheme. They were willing to sell their milk, but did not care to risk anything on the proposed plan. This obstacle was finally overcome by Mr. Andersen, who offered to buy their milk on his own account, and on this basis, partly "Fælles," the first coöperative creamery in Denmark was started in 1882.

It was a task of no little difficulty. There was no similar institu-

tion from which even a hint could be taken in regard to the best method of organization, or the drafting of the laws and regulations, which it became necessary to have ; but it was fortunate, very fortunate for the future of the enterprise, that those to whom this task or the first organization was assigned were able, far-seeing men. The constitution which was finally adopted proved to be so satisfactory that it has been more or less literally copied in the organization of all later coöperative creameries. This first plant, including building, machinery, and all dairy utensils, cost 8,000 crowns (\$2,160). The enterprise proved to be a success from the start, and those farmers who at first hesitated to join the organization, but preferred to sell their milk, one after another joined the company, and by the end of the second year all who delivered milk there were members.

The coöperative creameries have benefited the Danish farmers in more ways than one. They have been educators in addition to being the means of augmenting their incomes. The common interest which they had in the creamery brought the farmers together in frequent consultation, at which the brighter and more enterprising minds among them influenced the easier-going ones to adopt better methods. It compelled those who had not been in the habit of keeping accounts to study the art of bookkeeping in order to assure themselves that they received pay for all the milk they delivered.

The constitution usually requires a minimum amount of oil cake to be fed daily to each cow, and this, of course, had to be bought. This raised the question of cost of feed and the return in milk from the feed given, questions which were to be closely studied. And now every Danish farmer interested in a coöperative creamery is able to tell to the fraction of a cent what his feed has cost him and what his returns in milk have been. Under the Fælles creamery system the farmers sold their milk directly to the creamery man. They were not particularly interested in the quality of the milk. No practical test had at that time been devised by which the amount of fat in the milk could be ascertained with ease and certainty. Under the coöperative system they soon recognized that the milk from some herds was worth more for butter than from others, and, since butter was the product aimed at, they all conceded the equity of paying for the milk in accordance with the per cent of fat it contained. At this juncture Prof. Fjord came to their assistance by inventing his "control" apparatus, which has already been described (Fig. 12) in the foregoing pages, and his invention is now in use in every creamery in the land. Indirectly this testing apparatus led to the improvement of the cattle. When one farmer found that his neighbor received more money for his milk than he, it was natural to inquire into the cause, which, in most cases, was traced to the cow herself. This, again, led to the organization of numerous societies for the improvement of the cattle, one form of which is represented by the "bull associations" already mentioned; and thus

one question suggested another until the present standard has been reached. But they will by no means stop here. The same forces are still at work. Improvement in every line of the dairy interest is the ambition of the whole country. It is this wholesome development of the coöperative creameries which has increased the Danish exports of butter to the present astonishing figures, the amount having almost doubled during the last half-dozen years.

ORGANIZATION—OFFICERS, SALARIES, ETC.

When an organization is to be effected the farmers of the neighborhood meet together, and, having agreed upon the general plan, they elect a board of directors from their number. There is considerable difference, numerically, in the composition of this board in different organizations. Thus, the number of directors varies from three to fifteen. This board is charged with the duty of conducting the business of the creamery according to the requirements of the constitution which the organization adopts. A chairman, a secretary, and a treasurer are elected from among the board of directors. In some cases a small salary is paid to each, while in other cases they give their services. The board of directors hire a competent dairyman to take charge of the creamery. He, in all cases that came under my observation, had rooms in the building. Sometimes he is paid a salary only, at other times he is paid both salary and commission, this latter plan being the most common. He gets his commission from the surplus which the butter brings over the highest quotation on the exchange in Copenhagen, and he thus becomes financially interested in producing the finest quality possible. He also has certain allowances of milk and butter, and is furnished fuel, light, etc.

The salary of such a man will vary from \$270 to \$405 a year, in addition to his commission; or from \$432 to \$1,080 a year when he works without a commission. The board of directors hold him responsible for the operation of the creamery. According to the terms of the agreement he is either allowed a given sum with which to hire his helpers, or, as happens in many cases, he supplies the helpers himself and pays them out of his own pocket. In any case he is the only responsible person. When he pays for the help it is very generally the case that he gets young men and women who desire to learn the business and who work for a small salary in order to get the benefit of his instruction and become familiar with the details of the business.

The capital with which the plant is erected is, in nearly all cases, money borrowed at 4 per cent interest. The terms of the agreement usually require that a given amount shall be paid off each year for a period running from ten to twenty years, and each member of the organization becomes personally responsible for a share of the capital thus borrowed, in proportion to the number of cows that he has entered. In the meetings of the organization the members vote also

by the number of cows represented by each, or, in some cases, by the square root of the number of cows represented by each. When new members wish to join a body already organized, they must obtain their places by paying a certain amount of cash into the treasury of the association. The value of the partnership is usually based upon the amount of milk delivered and the profits made during the year preceding.

The methods of procedure in these creameries are so nearly alike that only a few examples are necessary to convey an idea of them.

KILDEVÆLD COÖPERATIVE CREAMERY.

This is a typical creamery, on the island of Zealand, some 12 or 14 miles from the city of Hillerød. I investigated this institution thoroughly, and am under obligations both to the president of the board of directors, Mr. M. F. J. Grónbeck, and to the superintendent in charge of the creamery, Mr. L. H. Larsen, who, with unreserved kindness, answered all my questions fully.

The building was a two-story brick, much like the pattern shown in Figs. 24, 25, and 26 (pp. 109, 110), although these illustrations are not identical with the building in question. The lower floor was devoted to the dairy alone. It was level with the ground, and was divided into only two rooms, the larger one of which contained the separator and the churn, and there also the milk was received. In the smaller room the butter was worked, cooled, and stored until shipment. A small "L" projecting back from the main wing contained the boiler and engine with storage room for coal, and back of this was an ice house. The necessary water was supplied by a good well, from which it was pumped by the engine into a suitable reservoir. The upper story was set apart for the superintendent and his family and also contained rooms for the helpers.

President Grónbeck kindly furnished me with the following facts concerning the plant: The association was organized in 1888, with 69 members, representing 400 cows; but, as they anticipated that others would join, they decided to erect a creamery with a capacity for 1,000 cows.

At first it was agreed that each member should pay into the treasury a sum of 27 cents per cow owned by him. This was raised to 54 cents, and later to \$1.35 per cow. The following is a statement of capital and expenses of the plant:

Capital.

Assessment of members at \$1.35 per cow.....	\$675.00
Loan from bank.....	8,640.00
Total.....	<u>9,315.00</u>

Expenses.

12,000 sq. ft. of ground for buildings and garden.....	\$400.92
Cost of buildings.....	3,995.40
Cost of machinery.....	3,148.82
Furniture.....	434.09
Wagons, milk cans, and utensils.....	1,052.85
Miscellaneous.....	133.71
	9,165.79
Later improvements.....	1,080.00
Total.....	10,245.79

The later improvements have been made from the profits of the business. The buildings have been constructed in the most substantial manner, and the machinery is the best obtainable. The business is in the hands of a board of directors, who elect their own chairman, secretary, and treasurer, and their actions are binding on the association.

The creamery began business the first of November, 1888, with 69 members, representing 400 cows, and in February, 1893, there were 177 members, representing 1,400 cows. The superintendent of the creamery was hired by the board of directors, and he had direct charge of the work in the creamery. His salary consisted in 6 per cent of the value of the butter made from the "overskud" (surplus). This term "overskud," which may be translated "surplus," is, when used in this sense, a little difficult to understand. They estimate that it requires 28 pounds of milk to make a pound of butter. Now if the creamery superintendent can make a pound of butter from 25 or 26 pounds of milk, the difference between that and the estimated 28 pounds is called the "surplus," and his wages consisted of 6 per cent of this and 20 per cent of the price which his butter realized more than the highest quotation made by the exchange in Copenhagen each respective week; in addition, he had furnished quarters, fuel, light, milk, butter, garden, etc., but out of this he paid for his hired help. The members of the company were paid for their milk once in four weeks, according to the per cent of fat in the milk, calculated by the system invented by Prof. Fjord. They got the price of a pound of butter for every 28 pounds of milk of average per cent fat, the highest quotation of the exchange each week fixing the price of butter; and if there was still a surplus in the treasury it was divided among the members in the form of a dividend twice yearly. In this creamery there had so far always been a considerable dividend distributed in this manner. The members were bound to take back their proportion of the skim milk and the buttermilk, and for this they paid the creamery 1 öre per pound, a trifle more than one-fourth of a cent.

The creamery provided the cans, fetched the milk from each farm, and brought each man back his proportion of the skim milk and the buttermilk; but the teams used were hired and paid for at the rate of

19 öre per 100 pounds of milk hauled. The skim milk was sterilized before it was returned, by being heated to a temperature 190° F. as fast as it ran from the separator. These were the fundamental principles on which the creamery was run, all of which I learned from the president of the company.

CONSTITUTION OF KILDEVÆLD CREAMERY.

To give a still clearer idea of the workings of a coöperative creamery I insert the following translation of the constitution of Kildevæld Creamery:

First. The object of the association is to secure to its members the best possible returns from their dairy cows. The milk shall be separated in common and from the cream butter shall be made and marketed. The members shall take back their proportion of the skim milk and buttermilk and shall pay for the same at about their actual value.

Second. Any one can become a member of this association by paying 1 crown per cow which he proposes to enter; provided, however, that not fewer than two-thirds of the votes cast are in his favor. But all who join after the creamery begins business shall pay 5 crowns per cow into the association's treasury. Each member shall on all occasions be entitled to vote as follows:

	Votes.
From 1 to 10 cows.....	1
From 11 to 20 cows.....	2
From 21 to 40 cows.....	3
From 41 cows upwards.....	4

Third. The association shall elect from their number a board of directors consisting of five members, and this board shall elect its own chairman, secretary, and treasurer, which offices must not be united in the same person. The board of directors shall represent the association in all business affairs, and their action shall be binding on the association. No member shall refuse to hold office when duly elected. The board of directors shall hold office five years, and the term of one of the original board shall expire each year during the first term, as determined by lot. Those who have once held office may decline reelection if they choose. The board of directors shall receive no pay, but they may employ a bookkeeper, at a salary not to exceed 40 öre per cow, and all necessary expenses incurred for the association shall be refunded from the treasury.

Fourth. An annual meeting of all the members shall be held each year in February, at which meeting the board of directors shall give an account of the business done during the past year and present plans for the business during the current year. At these meetings all differences that may arise between the board and members, or between the members themselves, shall be settled, and the meeting shall appoint an assessor and two auditors, the latter to hold office for two years, and one of those first appointed shall resign at the end of one year, as determined by lot. Amendments to the constitution shall require a two-thirds majority, but all other questions, not otherwise specified, are to be determined by a simple majority of the votes cast. Extraordinary meetings may be held at the call of the board, or upon the written request to the board of not less than one-third of the members. The board shall then give at least ten days' notice of the meeting to each member, who shall also be notified of the purposes of the meeting.

Fifth. The board shall contract a loan as large as necessary for the erection of the contemplated plant. For this loan each member shall be responsible, in proportion to the number of cows he enters, until all is paid.

Sixth. If a member sells or transfers his property, his share in the creamery shall pass to the new owner, if the latter will accept the privileges and responsibilities it confers; if not, the association shall pay the outgoing member only one-half of his share. No member can withdraw from the association before the debt is paid, except by removal from the neighborhood. Members desiring to withdraw after the debt is paid shall give at least three months' written notice of such withdrawal to the board of directors, and they shall be entitled to only one-half of their share from the association. Members who are expelled by the annual meeting shall lose their shares.

Seventh. The board of directors shall hire a superintendent for the creamery, who shall keep account with the members and shall be responsible for the work in the creamery. The superintendent shall hire, pay, and board all his help. He shall have at least one assistant who is a competent butter-maker, and at least one other assistant who is competent to take charge of the machinery (engineer). The superintendent of the creamery shall be paid quarterly, and shall be furnished quarters with garden, fuel and light, and the creamery products necessary for his household, and at the end of the year, when accounts are balanced, he shall be paid a premium for every hundred pounds butter sold at a satisfactory price.

Eighth. The milk shall be paid for in accordance with its content of fat, which shall be determined by the superintendent of the creamery. Milk of the average per cent of fat shall be paid for at the rate of the highest quotation for a pound of butter for each 28 pounds of milk.

Ninth. Until the debt of the creamery is paid the members shall be bound to receive their respective portions of skim milk and buttermilk, for which they shall pay about one-third of a cent per pound. After the debt is paid the price of this milk can be fixed at each annual meeting.

Tenth. The rates fixed in paragraphs 8 and 9 presuppose that there will be a surplus in the treasury over and above what is paid for the milk. This surplus shall be employed to cover current expenses, to pay interest, as well as the principal of the debt, as it falls due, or it may be divided among the members.

Eleventh. When the debt is paid, the president of the board, the assessor, and superintendent of the creamery shall assess the property of the company, which shall be assigned to the members in proportion to the amount of milk each has delivered since the business began. Thereafter the yearly profits shall be divided so that each member shall receive, first, 5 per cent of the value of his share, and if there is still a surplus in the treasury it shall be divided among the members in proportion to the amount of milk each has delivered during the past year.

Twelfth. The association shall provide and maintain the necessary number of milk cans and shall transport the milk to and from each farm; however, members who deliver less than 100 pounds of milk daily shall bring their milk to the nearest point on the highway where the transport wagons pass, and shall receive the skim milk in the same place. Members located off the main road shall keep the roads to their respective farms open and passable, and the milk cans shall be ready for the driver when he calls at the time named the day before.

Thirteenth. It shall be the duty of each member to keep his milk cans scrupulously clean, to see that strict cleanliness is observed in milking, and to strain the milk at once into the milk cans and place these in cold water, which shall be changed if necessary. Milk from sick cows must not be sent to the creamery, and milk from fresh cows must not be sent until four days after calving. It shall be the duty of the superintendent of the creamery to see that the milk is sweet and good. If the cans are not properly cleaned, or if the milk is objectionable, he shall give written notice thereof to the members interested, and if the fault is not corrected at once he shall refuse to receive the milk. If this happens a second time such member shall be fined two crowns for each cow in his herd. The members are forbidden to make butter or cheese for sale, and also to sell sweet milk to other

creameries; but they are allowed to retain what they desire for use in the household and to give away milk to poor people who do not keep cows. If desired, the members have the right to get their butter from the creamery at the same price that it will then bring on the market.

Fourteenth. It shall be the duty of the members to feed their cows in such a manner that the milk shall not be affected disadvantageously or the quality of the butter deteriorated. Cabbage, turnip tops, and kohlrabi tops must not be fed. Members shall notify the superintendent of the creamery of changes in feed, and keep him informed concerning the feeds used, so that he may give special attention to the milk. If the feed affects the quality of the milk or the butter, it shall be the duty of the superintendent to give written notice thereof to the member in question, and if the fault continues he shall refuse to receive the milk. The president of the board and the superintendent may, when they agree, forbid the use of any feed which they have reason to think is detrimental to the creamery. Members who refuse to be governed by their decision, or who do not live up to the regulation of this paragraph, shall be fined from two to ten crowns per cow, and pay for the injury they have caused the creamery as estimated by the president of the board, the superintendent of the creamery, and the assessor.

Fifteenth. To enable the members to obtain good feed stuffs at the lowest rate, the board, or a committee appointed for the purpose, may purchase such feeds at wholesale for the benefit of the members. It shall further be the duty of the members to buy rape-seed cakes enough for each cow to have at least one pound daily all the year through, and it shall be the duty of the board of directors to aid the members in feeding their cattle in an intelligent and economical manner, and, for example, by the purchase of seed, aid in the culture and use of plants which have a desirable influence on the quality of the butter.

Sixteenth. It shall be the right and duty of the board of directors and the superintendent of the creamery to inspect the premises of each member as often as they see fit, to note the quality of their fodder, pastures, cleanliness in stables and milk room, etc., and each member shall give all the information they may desire on these subjects, and if it can be proved that a member has withheld information wanted, or given them wrong information in regard to these matters, he shall be fined from two to ten crowns per cow and pay for the injury he may have caused the creamery, according to the estimates made by the president, superintendent, and the assessor.

Seventeenth. If any contagious disease appears either among the people or the cattle, on a member's farm, it shall be his duty to stop the delivery of milk at once until the disease has disappeared and proper disinfection taken place, and in case such disease appears at the creamery, the superintendent shall cause the sick person to be moved away and the place to be disinfected. To prevent possible transportation of disease in the milk, the skim milk shall be sterilized at the creamery before it is returned to the members. Non-compliance with the provisions of this paragraph shall be punished by fine in an amount not to exceed 100 crowns.

Eighteenth. It shall be the duty of the board to oversee the management of the superintendent and to see that the machinery and utensils are at all times in satisfactory condition, and particularly shall it be the duty of the board to give the whole creamery a thorough overhauling in regard to repairs every spring so that it may be in good condition for the warm season. At the close of the yearly account an inventory of the property owned by the association shall be taken jointly by the president of the board, the superintendent of the creamery, and the assessor, so that the members may always have a correct idea of the value of their common property.

Nineteenth. It shall be the duty of the board of directors to see that the cash on hand is employed to the best advantage of their association. The members shall be paid every four weeks for the amount of milk they have delivered, less the value of

the products they have received from the creamery. Division of the profits shall take place yearly after the annual meeting of the association.

Twentieth. In all cases when points arise not covered by this constitution the board of directors shall use their best judgment in the interest of the association, and, if necessary, bring the matter up at the next annual meeting, which alone is empowered to make alterations in or additions to these regulations.

Twenty-first. The board of directors shall have authority to buy milk for the creamery from farmers who are not members of the association.

Twenty-second. This constitution shall go into effect on and after the 27th of May, 1888.

I would call especial attention to those paragraphs in this constitution which are intended to enforce cleanliness in the handling of the milk, and which aim to compel the farmer to feed his cattle in such a manner that the milk shall not be objectionable. It is worthy of note that the board of directors are empowered to impose fines severe enough to deter any slovenly or careless person from breaking the rules. The fact that none can withdraw from the association until the debt is paid, except by removal from the neighborhood, unless he is willing to lose half his vested interest in the concern, is a feature which could probably not be put in force in this country.

All the essential features in this constitution are found in the constitutions of all the coöperative creameries, and although this represents but one of the many hundreds of associations which there are in the country, it is, nevertheless, a type of them all.

PRACTICAL OPERATIONS OF KILDEVÆLD CREAMERY.

The superintendent of Kildevæld creamery, Mr. L. H. Larsen, kindly gave me the following details concerning the operations of the creamery:

Although there were 1,400 cows entered by the members of the association, the creamery was receiving milk from only about 1,300 of them at the time of my visit, and from this number they obtain in round numbers 18,000 pounds of milk daily. A large majority of the members had only from 1 to 10 cows. A few had from 20 to 30 cows, but there were only two larger farms which contributed to the creamery, on one of which there were 60 cows and on the other 80. It will thus be seen that it was especially the small farmer, with only a few acres of land, who profited by the coöperative system. At that time of the year (February) it required 27 pounds of milk to make a pound of butter. The milk from all these patrons was tested twice each week, but the patrons did not know from what deliveries the samples were taken. They were paid in proportion to the per cent of fat contained in the milk. For this analysis Fjord's control apparatus was used, by means of which 192 samples could be tested at once. (See Fig. 12.) This apparatus can be used only in connection with the Burmeister & Waine separator, this machine having a larger bowl than the others. The bowl

is filled with water heated to a temperature of 133° F., the tubes of milk being warmed by it to this temperature. The separator is then run at a low speed, 1,500 revolutions per minute, for three-quarters of an hour. The cream has then formed a hard, perfectly solid mass in the opening of the tube. The thickness of this mass of cream is measured by means of a scale applied to the glass, and by reference to a table constructed by Prof. Fjord the per cent of fat can be told with accuracy.

All the patrons milk their cows three times a day, and the noon and the evening milk is kept in cold water, or ice water at the farms, until the following morning, when the transport wagon arrives and takes it, together with that morning's milk. As already stated, the creamery owns the cans and transport wagons, but the teams and drivers are hired and remunerated at from 5 to 7 cents per 100 pounds of milk hauled, according to the length of the route. All milk is tested upon its arrival at the creamery. If something is found wrong with it, and the superintendent is disposed to think that it is caused by one or more cows in the herd, he sends a case of small bottles to the farm and each cow's milk is sampled, and upon the return of these samples to the creamery the fault can frequently be traced to some individual animal, and her milk is then excluded until the fault is remedied. The milk furnished by each patron is of course weighed and the weight entered in the record.

From the receiving vat the milk runs through the "forewarmer," where it is heated to 84° F. in winter and 80° F. in summer before it runs through the separator. There were four of the Burmeister & Waine separators in use. From the separator the cream is discharged into tall cans which are sunk in ice water, one after another, as they are filled. The skim milk is raised by the separators themselves to a tank on the same level as the receiving platform, from which it runs through a pasteurizing apparatus, where it is heated to 190° F. From this it is discharged into a large tank from which the amount due each patron is weighed out and sent back. The price, as already mentioned, was one öre per Danish pound. There was no difficulty in getting the patrons to take the milk at this price and some were glad to get more than their share. This milk reaches the farms perfectly fresh and sweet. It is used largely for the manufacture of skim-milk cheese and to feed to calves and pigs. The buttermilk is in like manner returned to the patrons at the price given for skim milk.

When all the cream had been separated and cooled, about noon, the ferment was started. To this end the cream was first warmed to 64° F. In this creamery they used the somewhat troublesome method of warming it by setting the cans in hot water and constantly stirring their contents and testing with the thermometer until the desired temperature was reached. In most other places they used a pasteurizing

apparatus for this purpose. When the proper temperature was reached the prepared ferment was added, to the amount of from 6 to 8 per cent of the weight of the cream, and it then stood in the cream barrels for 18 hours, from noon until 6 the following morning, when the churning began. Mr. Larsen used pure culture ferment for his cream. He propagated this ferment from day to day in skim milk, and he found it necessary to buy new cultures only once in about two months. For propagating this ferment he used 200 pounds of fresh milk daily. This was secured from special cows which had calved only four or five weeks. He used the morning's milk. It was set in cold water immediately on arrival and skimmed by hand. After skimming it was pasteurized at 176° F. and then kept in warm water of the same temperature for 15 minutes, after which it was cooled to 82° F., when a portion of the ferment made in the same manner the previous day was added. This ferment was added about 2 p. m. The skim milk containing the ferment was then warmed to 88° F. by setting the cans in warm water, and by means of a steam pipe connected with the water-tank it was kept at the temperature until evening, when it was thick. It was then taken out of the warm water and set in cold water of about 50° F., where it remained until the next noon, when it was ready to be added to the cream. He considered this the best method. He deprecated the use of buttermilk as a starter, and would never use it unless compelled to do so.

The churns are started at between 5 and 6 a. m. At that season he churned at a temperature of 57° F., but in summer he frequently went as low as 52° F. The churning temperature varied with the character of the butter and with the weather. He judged of the required temperature by the character of the butter. The creamery was furnished with four churns of the pattern already described. The dasher in each made 130 revolutions per minute, at which speed it required forty-five minutes to churn. When the butter began to form in small granules the size of pin heads, the churns were stopped and the sides and lids were washed down with water at a temperature of about 50° F. Each churn contained from 400 to 450 pounds of cream, which filled it about three-quarters full. The butter was dipped out of the churn with a sieve or strainer and immediately worked a little on the butter worker to remove most of the buttermilk. It was then weighed and four and a half per cent of salt added, which was worked in lightly. The butter was next made into crescent-shaped rolls and placed in ice boxes made for that purpose (see Fig. 16). Here it stood for two hours, after which it was worked for the last time and at once packed in barrels holding about 110 pounds each. The butter was sent off every Monday. It was sold to a dealer in Copenhagen, who paid about \$1.00 per 100 pounds above the highest quotation on the exchange for the preceding week. The cream in this dairy was not pasteurized

before it was churned. All unfavorable conditions were so well under control that this was not found necessary. The leading pieces of machinery and apparatus in this creamery were as follows:

- (1) An 8-horse power engine.
- (2) A 10-horse power boiler.
- (3) Four "B. & W." separators, each with a capacity of 4,000 pounds per hour when run at a speed of 2,700 revolutions per minute.
- (4) Four churns of the usual pattern.
- (5) One "forewarming" apparatus for sweet milk.
- (6) Two Pasteurizing machines for the skim milk.
- (7) Three large milk vats, one each for sweet milk, skim milk, and buttermilk, besides several smaller ones used as occasion demanded.
- (8) Eight cream barrels.
- (9) One large butter-worker.
- (10) Several ice boxes in which to cool butter.
- (11) Three large water-tanks for cold and warm water.
- (12) Forty cream cans.
- (13) Six hundred cans used in the transportation of milk. They varied in capacity from 40 to 100 pounds.

Besides these, there was a large reservoir on top of the building which was always kept full of water, pumped by steam from a good well, and with this tank there were connections to all parts of the creamery where cold water was needed. In like manner a hot-water tank furnished hot water to all parts of the creamery, and there was a miscellaneous collection of smaller utensils not necessary to specify.

The working force of the creamery consisted of, first, the superintendent; second, an engineer, who had charge not only of the engine and boiler but also of the separators; third, a weighmaster, who weighed all the milk that came in or left the creamery and assisted with other things; fourth, a butter-maker; fifth, an assistant who had no special duties; sixth, two pupils, a young woman and a young man, who worked, however, the full time as did the others. All of these people received their pay, board and lodging from the superintendent of the creamery. The pupils got their board and a very small wage besides, for which they worked as much as would be required of a hired person. The other four assistants were paid according to their value, the total amount paid to all being about \$300 per year, besides board and lodging.

The accompanying summary of the business of the creamery for the years 1889, 1890 and 1891, which I obtained permission of Mr. Larsen to transcribe from his books, will give a clear idea of the profit to the patrons as well as the business of the creamery in a more condensed form than any description could give.

Information from Kildevold creamery.

General statistics.	1888-'89.	1889-'90.	1890-'91.
Pounds sweet milk delivered.....	4,614,831	5,712,081	6,395,909
Average number pounds received daily.....	12,643	15,649	17,523
Average number pounds received from each member.....	134	173	179
Number of cows.....	945	1,115	1,240
Average number pounds from each cow per day.....	13.37	13.53	14.22
Number pounds per cow per year.....	4,883.40	4,939.50	5,157.90
Pounds milk required for each pound butter.....	29.31	30.12	29.39
<i>Receipts per 1,000 pounds of milk.</i>			
Butter.....	\$9.93	\$9.33	\$9.91
Skim milk and buttermilk.....	2.57	2.57	2.60
Total.....	12.54	11.90	12.51
<i>Expenses per 1,000 pounds of milk.</i>			
Transportation.....	\$0.29	\$0.35	\$0.37
Fuel.....	.18	.15	.15
Wages.....	.22	.20	.22
Butter packages.....	.18	.14	.16
Capital and interest due.....	.10	.17	.16
Repairs.....	.14	.21	.05
Total.....	1.11	1.22	1.11
Cost of making 1 pound butter.....	0.027	0.03	0.027
Paid to members.....	10.37	9.69	10.34

A TYPICAL COÖPERATIVE CREAMERY.

I append here illustrations of a coöperative creamery calculated to handle the milk from about 700 cows. I did not find time to visit this creamery, but the illustrations presented, with their explanations, will serve to convey an idea of the construction and equipment of the typi-



FIG. 24.—A typical coöperative creamery.

cal coöperative creamery. Fig. 24 gives a front view of the building. On the left is seen the driveway in which the milk is delivered. There are rooms above for the accommodation of the superintendent and help. Fig. 25 shows a section of the same building with some of the appa-

tus in place. Fig. 26 shows a ground plan of the same. *A* is a stable, *B* coal room, *C* driveway, *D* the main dairy room, *E* butter room, *F* cheese room with cellar below, *G* office, and *H* a raised platform on which

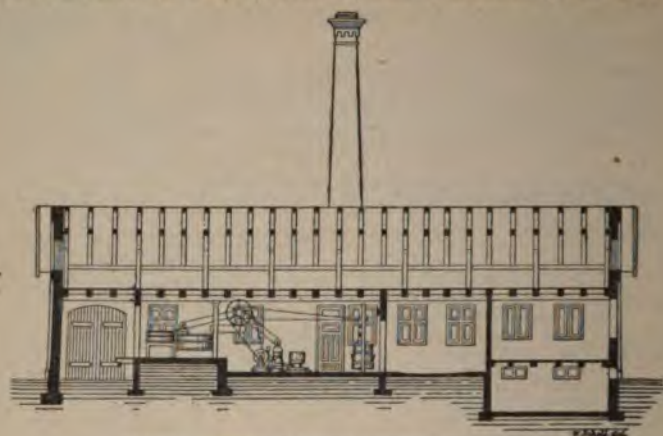


FIG. 25.—Section of typical coöperative creamery.

the milk is received and weighed. The machinery is designated as follows: a_1 and a_2 two separators, b a forewarmer, c_1 and c_2 represent two churns, d cheese vat, e vat for sweet milk, f vat for skim milk, g tank for hot water, h butter worker, and s sterilizing apparatus.

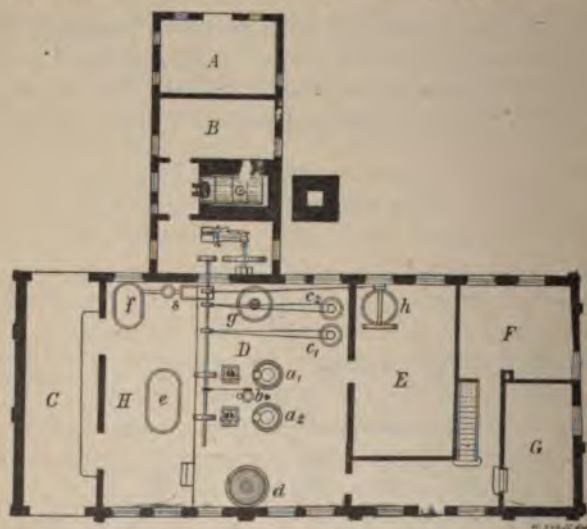


FIG. 26.—Ground plan of typical coöperative creamery.

I will here add an illustration (Fig. 27) which has been prepared by H. C. Petersen & Co., manufacturers of creamery goods, Copenhagen. It shows the arrangement of the machinery in a well-equipped dairy, and although it is an idealistic arrangement it corresponds with the arrangement generally found in the coöperative creameries. It is best studied

by following the milk and cream through the various machines. The milk is carried from the delivery wagon *A* to the weigh box *C*, into which it is emptied. From this it runs into the vat for sweet milk *D*, and through the pipe *d* into the forewarmer *E*, and from this into the separator *F*. The skim milk rises of itself through the pipe *L* and through the trough *l* into a small suspended vat *M*. This vat is found necessary in order to give the froth time to settle. From this it runs into the pasteurizing apparatus *N* and from here over the cooler *O* into the skim milk vat *P*. From this it is drawn into the cans *R* and weighed on the scale *S* and then disposed of to customers. If cheese is made, the skim milk runs directly into the cheese vat from the sepa-

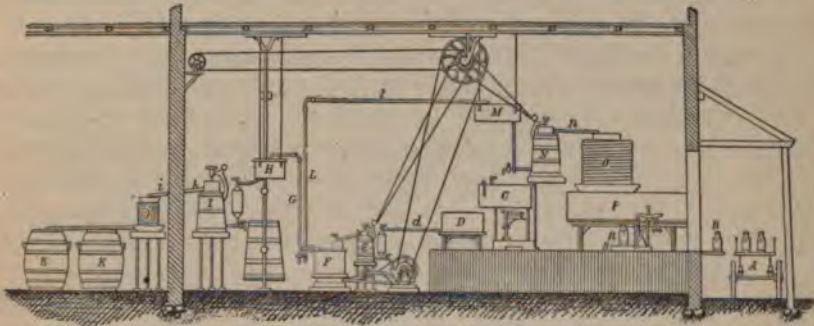


FIG. 27.—Arrangement of machinery in creamery.

rator. The cream leaves the separator through the pipe *G* into the small suspended vat *H*. From this it runs through the pasteurizing apparatus *I* over the cooler *j* and through the trough *j* into the cream barrels at *K*. The whole is arranged on the gravity plan, so that the milk or cream can run of itself to any place it may be wanted.

RENKOLDE COÖPERATIVE CREAMERY.

I mentioned this creamery briefly in my preliminary report. It is organized exactly on the plan just described and run on the same methods. The plant consisted of a large, substantial brick building with rooms for the superintendent and help. The ground and building with ice house cost about \$5,400 and the machinery \$2,835 and later additions and utensils and improvements cost \$405, making a total of \$8,640. All this money was borrowed from a bank at 4 per cent interest, to be paid off in sixteen years, at the rate of \$540 per year. It had been running only a few years, but had so far been entirely successful. The patrons were paid the maximum quotation per pound of butter for 28 pounds of milk, 28 pounds being the standard assumed as necessary to make a pound of butter. It is, however, only in a few instances that it requires that much milk. The superintendent was paid a certain per cent of the profits, as is usually the case, and he hired his help, which consisted of two men and two women. During the past

year the surplus, after paying the patrons at the rate stated above for milk delivered, was sufficient not only to pay all running expenses, but to pay the interest, the \$540 falling due on the capital invested, and still give each patron a dividend of about 17 cents for each 100 pounds of milk delivered. The superintendent informed me that he, at that time of year, only used 15 pounds of milk to a pound of butter, and that in summer he used 29.5 pounds. They received, at that time, milk from about 1,100 cows daily, from which they made on an average 350 pounds of butter per day. The arrangement of the building was the same in pattern as the one already described, with only slight differences. Near the center of the building was an arched gateway for the wagons to drive through, and on one side of this was the creamery and on the other the rooms for the superintendent and his help. The delivery and weight platform was raised to the height of a wagon box, but the other portions of the building were on a level with the ground. There was first a large room, in which the machinery was placed. Beyond this was a butter room, where the butter was worked and packed. Next to this a storage room, which stood in immediate connection with the ice house. The engine was placed in a small "L" projecting from the main building. The creamery was equipped with an eight horse-power engine, three separators, and two churns, with the necessary smaller utensils, water tanks, etc. The skim milk and buttermilk were taken back by the patrons who paid three-fourths of an öre per pound.

RINGE COÖPERATIVE CREAMERY.

On the island of Funen I visited a representative coöperative dairy in the village of Ringe, where Superintendent L. Rasmussen kindly gave me the following details in regard to the business: The building was of brick, with cement floors and excellent drainage arrangements. The association was organized five years ago, and then represented 500 cows. Each member paid \$2.70 per cow entered by him, which made a total capital of \$1,350. The cost of the plant was \$6,588. The balance of \$5,292 was borrowed at 4 per cent interest, with notes for \$540 falling due each year until all was paid. Each member was responsible for the debt in proportion to the number of cows entered. At the time of my visit there were 214 members, representing 700 cows. They were paid, as in other cases, the maximum price of a pound of butter for 28 pounds of milk. The organization differed from those already described in that the farmers were not compelled to take back the skim milk and buttermilk, but those who wanted it got what they required at about one-fourth of a cent per pound. The skim milk not sold was made into cheese at the creamery. They received at the time of my visit about 10,000 pounds of milk daily, in round numbers. The milk was raised to a temperature of 86° F. by running through a "fore-warmer" before it ran into the separator. The cream was cooled with

ice water as soon as separated, and about noon the prepared ferment was added, and by 6 a. m. the following day it was ready to churn. It was churned at 56° F., and butter usually came in thirty-five minutes. The superintendent worked the butter the first time by hand, after which it was laid away to cool for two hours; it was then worked on the butter-worker, 4 per cent of salt added, and immediately packed in barrels for shipment. It was kept in cold storage while in the creamery and sold once a week. Mr. Rasmussen prepared his own ferment from hand-skimmed milk in exactly the same manner as described for the Kildevæld creamery. The skim milk was sterilized at 185° F. From the sterilizing apparatus it ran into a large vat, from which the orders from the farmers were filled, and what remained was made into skim-milk cheese, of which they made about 170 pounds daily. It required 16 pounds of milk to make a pound of cheese.

The milk was warmed and the rennet added in the manner already described. The cheese remained in the press for twenty-four hours. It was then put in strong brine for twenty-four hours and next put in the cheese-room, where it was daily wiped and turned for a month, and when the rind began to harden it was washed daily with brine. Their cheese sold, wholesale, for 4½ cents per pound avoirdupois. Patrons of the creamery had the privilege of buying cheese and butter at a trifle lower price than that asked in the market. The establishment was equipped with a seven horse-power boiler, a five horse power engine, a DeLaval "Alpha" separator, with the necessary line of tanks, cream barrels, buckets, etc., and also a line of cheese-making utensils. The superintendent in this creamery received about \$272 per year as salary, with house, fuel, light, and dairy products, and 25 per cent of the receipts for butter above the top quotation by the exchange in Copenhagen. Out of this he paid and boarded his help, of which there were four persons: first, a chief dairywoman who got \$67.50 per year and board; second, a young man who got \$59.40 a year and board; third, a young man who got \$33.75 per year and board, and, lastly, a dairy pupil, a young woman, who got \$16.20 per year and board.

SNÓDE AND STOELSE COÖPERATIVE CREAMERY.

The superintendent of this creamery, Mr. P. Andersen, kindly furnished me with the following information: Eight thousand one hundred dollars was invested in the plant. Of this sum the building site cost \$378, the building \$2,970, machinery \$2,970, and furniture and all other dairy utensils, with some other further improvements, some \$1,782. All of this was borrowed money, on which interest was paid at the rate of 4 per cent per annum. Five thousand four hundred dollars were to be paid back in ten years, at the rate of \$540 a year, and the remainder was to stand indefinitely. The association contained only 123 members, who had entered 650 cows. At that time

the receipt of milk amounted to only 6,000 pounds daily, but in summer time this was more than doubled. From this was made an average of 210 pounds of butter daily, which in summer arose to 550 pounds. The members were paid, as in other places, the highest price per pound of butter for 28 pounds of milk; but they possessed a good class of cows, and it required only 26.6 pounds of milk to make a pound of butter. Fjord's control apparatus was used to test the milk, and all the milk was tested at least twice a week. It was not compulsory on the members to take back the skim milk and buttermilk, but it was sold to those who wanted it at about one-fourth of a cent per pound for buttermilk and one-third of a cent per pound for skim milk. All the skim milk not disposed of in this manner was made into cheese. That little creamery produced annually 121,000 pounds of cheese, or at an average rate of about 330 pounds daily. The cream was not sterilized because it was not found necessary. The strictest precautions to maintain absolute cleanliness were taken at every step, and they never had any cause to sterilize the cream. In winter the churning temperature was at about 60° F.; in summer it was somewhat lower. The churn was of the usual pattern, the dasher making 150 revolutions per minute. When granules began to show in the churn it was washed down with a few quarts of water of the same temperature as the cream. The butter was worked as soon as taken out of the churn for the removal of the buttermilk, and 4 per cent of salt added at once. One hour later it received a second working. It was then placed in a cooling-box, and in winter a third working was given it in two hours from the last, but in summer it remained in the cooler until the next morning, when it received the final working and was packed. Superintendent Andersen did not find it necessary to use any butter color. In fact, there are many places where none is used, and only little is added where color is used at all.

There being so much cheese manufactured, I obtained details in regard to the method followed. The skim milk was warmed to 85° F. and 14 per cent buttermilk was added and stirred violently and rennet added. It then stood for thirty minutes, when the curd was cut and stirred slowly, and at the same time the temperature was raised to 90° F. by injecting steam under the vat. When the whey was clear it was drawn off, and three-tenths of a pound of salt was added to the curd for every 100 pounds of milk, and worked in by hand. It was next put in the cheese cups and a light pressure applied. At the end of an hour it was taken out and turned and replaced under the press. Ten hours later it was turned again, and the following morning it was taken out and put in brine, where it remained for twenty-four hours. From the brine it was put into the cheese room, which was so arranged that it could be heated at pleasure by the waste steam from the engine. It was first placed near the steam pipes where there was a temperature of about 77° F. in winter; here it remained four days, being daily turned and wiped. After

that it was gradually moved into a cooler temperature, remaining, however, in the cheese room for three months. If stored after that it was kept at a temperature of 55° F. The price received varied considerably with the market, the maximum being about 6¼ cents per pound avoirdupois. The whey was sold to farmers at about one-twelfth of a cent per pound.

NONNEBJERG FÆLLES CREAMERY.

This creamery is, in several respects, the most interesting commercial creamery I visited. It is located at the city of Skanderborg, and is owned and operated by a noted bacteriologist, Mr. E. A. Quist, who, in his laboratory connected with the creamery, prepares the pure cultures which I have already had occasion to mention. By the courtesy of Mr. Quist I was permitted to look into the details of his business. The plant consisted of a large and very substantial brick building (Fig. 28), the cost of which is immaterial, since it also contained a laboratory and other compartments not essential to a creamery. Mr. Quist bought the milk from about 1,500 cows, but at the time of my visit



FIG. 28.—Projection of one side of Quist's creamery building.

the supply amounted to only 10,000 pounds daily. He had built and equipped this creamery chiefly to afford him opportunities for testing his pure cultures, and as he was compelled to pay a high price for the milk the profit was not great. However, the equipment of the creamery and the management of the product reached the highest point of modern skill attainable under the conditions there presented.

The sweet milk was sterilized as soon as received, at a temperature of 167° F. It ran directly from the sterilizing apparatus into the separators. Mr. Quist had tested the effect of separating at different temperatures, and he found that the milk was skimmed cleaner when run through the separator at about 167° F. than it was when separated at any lower temperature. He would under no circumstances separate at a lower temperature than 95° F. He found that at 167° F. there remained fifteen one-hundredths of 1 per cent of fat in the milk; at 95° F. there remained nineteen one-hundredths of 1 per cent, but at 77° F.

analysis showed that there remained twenty-two one-hundredths of 1 per cent of fat in the milk; and he maintained that, aside from the fact that the milk was sterilized, it was economy to raise it to that temperature in order to skim it cleaner. He used two Burmeister & Waine separators, as he maintained that they had advantages over others. They can raise the skim milk and cream to a height of 8 feet through pipes which can be directed to any part of the creamery, and much work in handling milk and cream is thus saved. Again, the latest pattern of this separator, which I saw in use there, was provided with a lid which could be closed perfectly air-tight. There is, however, a suction of air into the bowl when the machine is running; this air was admitted through a tube filled with sterilized cotton, which thus, as it were, strained the air before it came into contact with the milk and cream. Both milk and cream were run from the separators directly to coolers. In this case Smith's round cooler was used, which lowered the temperature to 46° F. These coolers were provided with a cap, or sort of lid made of tin, which fitted closely, and was designed to exclude the air as much as possible while the cream was trickling slowly down the sides. The notion that the coolers served any good purpose by aerating the milk is a mistaken one. It would be much better if the air were excluded, as the milk or cream becomes impregnated with bacteria from the air when thus exposed in a thin sheet over the sides of the cooler. The sole object in cooling the milk is to thus reduce the temperature so that the bacteria will cease to grow, and not, as is sometimes advocated, to expose the milk to the air, which has no effect on the creaming quality of the milk. When all the milk for the day had been separated Mr. Quist warmed a portion of the cream to 160° F., and this was mixed with the bulk of the cream in order to raise it all to a temperature of 68° F., and at this temperature he added 12 per cent of his pure culture. Cream thus prepared stood from 1 p. m. till 7:30 a. m. the next day, when it was ready to churn. The pure culture was used every day if the milk was not sterilized, as was sometimes the case; but when the milk was sterilized daily he used pure culture only once a week and buttermilk the rest of the time. When the milk was sterilized it was found that the cream required nearly twice the amount of pure culture in order to cause the proper degree of fermentation in the desired time than was needed when not sterilized. Sterilized cream, on the other hand, did not require such close watching. If kept at a given temperature it would always attain a given degree of acidity in the allotted time, and the souring could also be permitted to go further without injurious effects.

The churns were of the usual pattern of the country. The churning temperature varied with the season. At the time of my visit it was 57° F., but in summer it frequently went as low as 52° F. The butter was dipped out of the churn with a sieve, placed on the butter-worker, the buttermilk pressed out, and immediately afterward it was weighed

and 5 per cent of salt added, thus giving it two workings at once. The third working took place three or four hours later in the winter, the butter being kept in a cooling box in the meantime; but in the summer it was not worked the last time until the next morning, being kept in the cooler all the time. Immediately after the last working it was packed in barrels of the usual size and placed in the storeroom to await shipment. Mr. Quist was particular to stop the churn at the right moment, not only for the sake of the consistency of the butter, but he maintained that if it was churned too long, or churned at too warm a temperature, the butter would contain a greater per cent of water than otherwise, and this affected its quality. The skim milk from this creamery was, for the most part, sold to people in the city, and that not disposed of in this manner was fed to swine.

I note the following points in regard to this creamery: (1) It was a solid brick structure which might last for centuries; (2) the ventilation was perfect; air could be admitted from all sides and the warm air could be let out by means of the ventilator in the roof; (3) it was constructed on the "gravity" plan; milk and cream could run directly to any desired place without having to be transported in buckets, thus saving a large amount of labor; (4) the floors were of natural Trinidad asphalt, and aside from being durable they could be kept scrupulously clean, and the drainage arrangements were perfect. I could not help comparing this to the wooden floors in our American creameries full of cracks and crevices, in which bacteria breed to perfection and through which not unfrequently bad odors arise from the water-soaked ground below.

The machinery and utensils had cost the owner the sum of \$3,240. I enumerate the following:

- (1) An eight horse-power boiler.
- (2) A six horse-power engine.
- (3) Two "B & W" separators, each with a capacity of 2,800 Danish pounds per hour.
- (4) A receiving weight, on which rested a balanced weighing can, with a capacity of several hundred pounds. When the desired amount of milk had been weighed a light touch tilted this can so that the milk was discharged into—
- (5) The receiving tank. A large, square can of heavy tin.
- (6) A "forewarmer" or sterilizing apparatus, where the milk was heated to the desired temperature.
- (7) The separators, which raise the cream through brass pipes to a little tin pan suspended from above, from which it runs through—
- (8) Smith's cooler, which, in turn discharges into barrels.
- (9) The skim milk is in like manner raised to a small tank above, directly from the separators, from which it runs to the delivery tank or through the sterilizer, as may be desired.
- (10) A pump forced the water used in the coolers in a circle from a reservoir, filled with ice above the cooler, through the cooler and back again to the reservoir. This arrangement made it possible to save a good deal of ice, since the same ice water was used over and over again.
- (11) The same pump was also used to convey buttermilk from the churns through a hose to a tank in the delivery room, where it was weighed out to customers.

- (12) Two Smith's coolers, which have been described elsewhere.
- (13) Two cream barrels, double, a tin can being fitted in an oaken casing.
- (14) Two churns, also of oak wood.
- (15) A large revolving butter-worker, of the American pattern, but which was highest in the center, so that the fluid as it was pressed out ran to the circumference.
- (16) An oak-wood butter trough, serving more especially as a table.
- (17) Two butter-coolers, of the pattern described and illustrated under Dairy Implements.

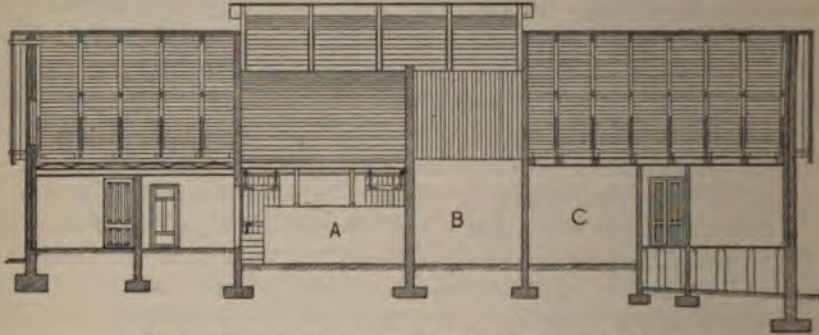


FIG. 29.—Vertical section from end of Quist's creamery building.

- (18) A butter weight, on which the butter is weighed after the first working, in order to ascertain the required amount of salt.
- (19) In a separate room cement basins for ice water in which to cool milk when this is desirable.
- (20) A large cheese vat with copper bottom.
- (21) Cheese presses.
- (22) In wash room a hot-water tank, from which the necessary amount of hot water could be had at all times, when the engine was running.
- (23) In the same place a steam jet, with arrangement for sterilizing all milk cans and other utensils.

I give herewith further illustrations of Mr. Quist's creamery. Fig. 29 shows a vertical section, from end to end, of the creamery. A is the

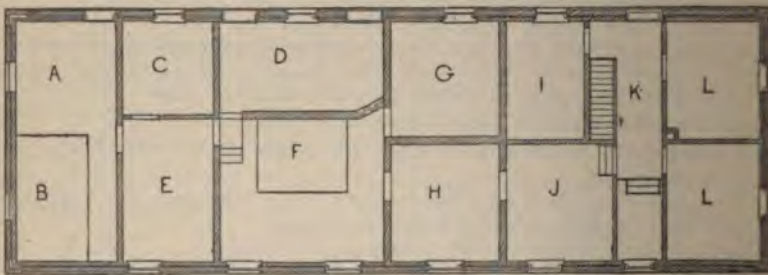


FIG. 30.—Plan of Quist's creamery building.

raised platform on which the milk is received and weighed and from which it runs down to the separator, B is the churning room, and C the room in which the butter is worked. The ventilator over the work room is a noticeable feature. This ventilator could be closed or opened at pleasure. Fig. 30 is the plan of the building. A is the coal room, B the boiler room, C the cheese room. This room could be warmed by

steam from the boiler. *E* the engine room, *D* the platform on which were the milk vats, *F* the separating room below this platform, *G* the wash room, *H* the churning room, *I* office, *J* the room in which the butter was worked and cooled, *K* hall, and *LL* laboratories. There were rooms above the laboratories for the accommodation of the help.

To these descriptions I could add much more material of the same nature, but I trust that the methods described in the foregoing cases will enable creamery and dairy men to get a reasonably clear idea of the practice in the Danish dairies.

DAIRY BACTERIOLOGY.

It is only between two and three years since the use of pure cultures of bacteria were introduced into the creameries of Denmark, as a means of improving the butter, but the results have been so uniformly successful that they are now used in all dairies whenever there is necessity for them. The honor of the introduction of this improvement in creamery methods does not belong to any one man, though, perhaps Prof. V. Storch, director of the experimental laboratory at Copenhagen, deserves the "lion's share" of the credit. He has been at work on the problem for some six or eight years, and from time to time has published the results of his researches. Other bacteriologists took up the same line of work, and the result was that pure cultures of the beneficial bacteria were put upon the market by the three different laboratories at about the same time. Prof. Storch had already then isolated and cultivated several forms of these bacteria, but he has not put any of them on the market.

As the several investigators worked independently of each other, each can be credited with an original discovery, especially since the bacteria employed are not the same in all cases. From the investigations by Prof. Storch, Prof. Fjord, and others, it soon became evident that the quality of the butter depended, at least in a large degree, on the presence or absence of certain minute organisms. It was found that in faulty butter certain forms were present which, when isolated and cultivated, produced the characteristics which were objectionable. In like manner it was found that in high-class butter certain other forms were present, which would, in like manner, produce the characteristic aroma and flavor when cultivated by themselves. This led to the natural recognition of two general classes of bacteria, one of which was injurious to the interests of the dairy, and the other one beneficial. When this fact had been settled, the practical question before the investigators was how it would be possible to repress one class and encourage the other. Prof. Fjord had, in the meantime, perfected his pasteurizing apparatus, which has been figured and described elsewhere. This was invented chiefly with a view to improve the keeping qualities of skim milk so that it might reach the patrons and other con-

sumers in a fresh and sweet condition. This was accomplished by heating it to a temperature of upwards of 150° F. It was found that this temperature destroyed enough of the bacteria which caused the milk to change to make it possible to keep it sweet for from twelve to twenty-four hours longer than when it is not thus heated. The next step was to apply the same treatment to the cream, or to the sweet milk before it was separated, with the same results. Heated to a temperature of between 150° and 160° F., or upwards, it was found that the most active forms of the bacteria were killed, and that by again cooling the cream to about 75° or 80° F., at which bacterial life becomes active, the cream could be inoculated by any desirable form of bacteria if these could be obtained from pure cultures, and that the forms with which the cream was thus impregnated, meeting with no opposition from other forms, would develop rapidly in enormous numbers and give their peculiar characteristics to the butter. This is exactly what is now done in practice. The cream is not always pasteurized because, if there are no injurious bacteria present, at least in such numbers as to cause a deterioration of the product, there is no necessity for attempting to kill them, and the addition in sufficient quantity of a pure culture would at once give the latter the upper hand, and their peculiarities would become prominent. A rather more thorough sterilization would be effected if the milk were raised to the boiling point; but a temperature of much over 160° F. gives the characteristic boiled taste to both milk and cream, which is objectionable and must be avoided. It is found in practice that this temperature destroys nearly all the organisms in active growth. The spores will survive this temperature, but it takes them longer to develop and by the time they become ready the pure culture has the mastery.

As a higher degree of heat than that required for their normal development is destructive to the bacteria, so in like manner a reduction of the temperature retards their growth. It does not destroy them, if not below the freezing point, but it stops their development and renders them inactive. It is for this reason that pains should always be taken to reduce the temperature of the milk, by means of ice water, to a point as near the freezing point as practicable. Heat and cold, relatively speaking, are therefore effective means in controlling bacterial life in the creamery.

There were at the time of my visit three laboratories in which pure cultures were propagated and sold to the dairies. One of these was the laboratory of Christian Hansen, the famous butter color and rennet manufacturer, whose products are well known in this country. Another was a firm of chemists named Blauenfeldt & Tvede. Both of these laboratories were in Copenhagen. A third laboratory belonged to Mr. E. A. Quist, of Skanderborg, whom I have already had occasion to mention in the description of his creamery. These dealers in the pure cultures keep their methods of propagation secret. The isolation of the germs

can, of course, be accomplished by any bacteriologist; but they claim that it is only through a long series of experiments that they have hit upon a composition for the nutritive fluid in which to grow them to best advantage. It also requires certain forms of apparatus to which they may lay claim as inventors, and these features they do not propose to divulge, as it would probably increase competition to a point beyond profitable production. Moreover, I was informed that each form of these minute organisms had to be treated in a manner peculiar to itself, and as the several growers did not deal in the same bacterial forms, their methods of treatment in the laboratory were not alike. How many forms of the beneficial bacteria are in existence is at present unknown; but it is known that they are numerous. A dozen or more forms have already been discovered. Blauenfeldt & Tvede informed me that their culture contained many forms, but how many was not stated.

Mr. Quist, on the other hand, uses only two forms, which I had opportunity to study through the microscope. There was a decided difference in the smell and taste of the preparations offered by the two firms. Blauenfeldt & Tvede's cultures had a sharp, sour taste and smell. Mr. Quist's cultures were less acid and possessed a peculiar nutty aroma, such as we find in the best samples of butter. I have had opportunity to see the effect of Mr. Quist's culture in this country. I bought samples of him which he shipped to the Department of Agriculture. A portion of these samples was forwarded to me, and I tried them in the Belle Springs creamery, owned by Mr. J. E. Nissley, the president of the Kansas Dairymen's Association.

The cream was not sterilized before the cultures were added, but they had a decided influence on the butter. Both Mr. Nissley and his butter-maker pronounced the quality superior to any they had made formerly, and they at once became converts to the process. I forwarded samples of the pure cultures to Prof. H. C. Wallace, who has charge of the dairying in the Iowa State Agricultural College, but I have at this writing not heard with what results they were used. In Denmark, where the cultures will be in transit at most only a couple of days before they reach their destination on the dairy farms, they are put up in a preparation of skim milk; but in shipping to this country, where they may be in transit for many weeks, they must be specially prepared in order to retain their activity the necessary length of time. The samples shipped by Mr. Quist were sent in three mediums; one a preparation of milk sugar; another in sterilized cotton, and the third in a nutritive fluid of his own invention. At the Belle Springs creamery we used only the first and the last of these. Although they had been in transit from the 10th of March until the 5th of June, they appeared to be perfectly fresh and ready for business. The cotton preparation I did not try. Should any of our creamery men decide to try Mr. Quist's cultures, they can be had without fear of deterioration on the journey. It is, however, to be supposed that our bacteriologists will soon take

this matter in hand and give us pure cultures within easy reach of the creameries in this country. The American branch of Christian Hansen's laboratory prepares and sells the pure cultures, which had their origin in his laboratory at Copenhagen.

CONSTRUCTION OF ICE HOUSES.

Ice being used so largely in the Danish dairies, they have given considerable attention to the construction of ice houses. Formerly it was customary to store the ice in a pit in the ground, this pit being dug on a hill or rising ground, so that a drain could be laid from the bottom of it to carry the water off readily. These pits were walled up with brick or granite and covered with thatch. But it was found that this construction was neither convenient nor economical, and it has long since been abandoned. Their ice houses are now constructed above ground, and, whenever practicable, in direct connection with the creamery. Although ice is not a scarce article in that country, it has been found more economical to build a substantial ice house with double walls

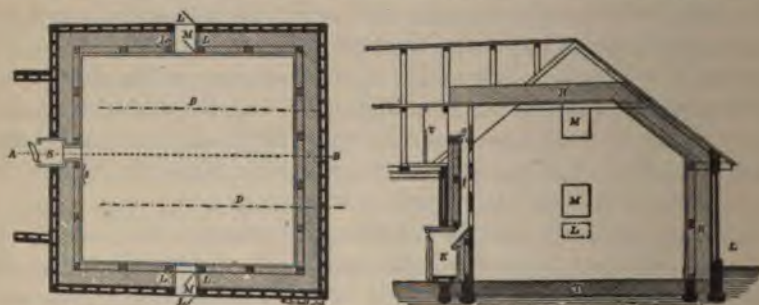


FIG. 31.—Ground plan and section of ice house.

than to put the ice in a flimsy structure with thin walls, through which the changes of temperature are readily felt.

Fig. 31 shows the plan and section of an ice house of modern construction, built in connection with a creamery. Both the outside and inside walls are, in this case, of wood, but they are also frequently built of brick. The plan shows that the outside studding is boarded up on both sides. On the outside, ordinary weather-boarding is used, but on the inside it should be made as tight as possible. Inside of this shell, and 2 feet from it all around, is another set of studding which is also boarded up on both sides, the boards being fitted nicely together. The 2-foot space between these two walls is filled with some non-heat-conducting material, chaffed straw or hay being the most common. Any material thus used will, in the course of two or three years, have gathered moisture so that it will begin to mold, or, if it is of a nature which prevents its molding, it will nevertheless be moist, and in this condition it has partly lost its non-conducting properties and it ought to be renewed. It is therefore essential to have small doors at con-

venient places in the outside shell, near the ground, through which the packing can be removed, and others near the top through which it can be renewed. The space is large enough to admit a person to tramp it together.

The ice house here represented opens into the creamery and, in this case, no special anteroom is therefore needed; but if the entrance is from the outside an anteroom is essential in order that the warm air may be excluded from the ice house on entering. In the section of this ice house the letters *H H* represent the chaff which is packed in between the double walls. *M M* are doors through which the ice house is to be filled and *L L* are doors used for the renewal of the chaff. The letter *T* represents a layer of peat on which the ice rests. It will be noticed that the layer of chaff extends over the ice as well as up the sides of the building. The ice is removed through the chute *t* and falls into the box *K*, from which it is removed as wanted during the day. Entrance to this ice house is gained at *V*, under the ceiling, where there also is a window to admit some light. In the plan the letters *L* and *M* represent the openings, the same as in the section. *K* is the box into which the ice is thrown, *D D* are drains which carry off the water as the ice melts and the line *A B* represents the point at which the section is drawn.

In this connection it is interesting to note an experiment carried out by Prof. Fjord to ascertain the efficiency of the substances named as packing materials to be used between the walls of ice houses. The results are based upon the amount of water obtained from melting ice kept in an ice box, placed in a warm room, and the double walls of which were successively filled with the materials named. Chaffed straw is taken as the standard and represents 100. The figures are as follows:

Chaffed straw	air dry..	100	Wheat straw	air dry..	110
Cotton	do...	79	Peat dust	do...	116
Barley hulls	do...	90	Sawdust	green..	170
Wheat chaff	do...	92	Peat	damp..	260
Oat chaff	do...	94	Sawdust	wet..	260
Dry leaves	do...	96	Earth	do...	560
Rice hulls	do...	101	Sand	do...	630
Buckwheat hulls	do...	104			

The proper use of ice in storerooms is also an important point. In connection with the experimental laboratory in Copenhagen is an exhibition building for dairy products. It is in this building that the frequent competitive exhibitions of butter from dairies all over the country are held. It is essential that the butter should be kept at a low temperature, and to this end Prof. Fjord constructed an ice house in connection with it which is so arranged that the air which enters the storeroom must pass over the ice in the ice house. There are ventilators placed near the bottom of the wall which separates the ice house from the storeroom, and the cold air from the ice house flows through these into the storeroom. The principle is illustrated in Fig. 32, the

arrows showing the course of the air currents. The cold air comes out from the ice directly under the butter packages, and as it becomes warmer it rises and again enters the ice house, or large ice box, as the case may be, at the top. It is a principle which it may be advantageous for our creameries to put into practice.

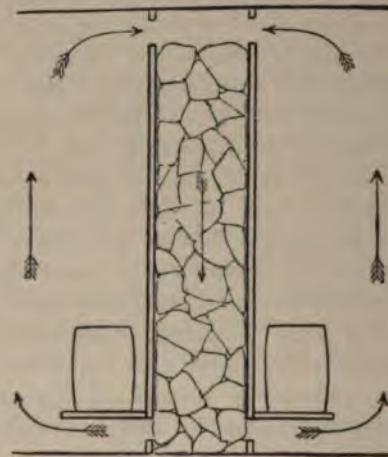


FIG. 32.—Use of ice in storeroom.

STATE AID TO THE DAIRY INDUSTRY.

As I have shown in the early portion of this report, dairying is the chief industry in Denmark, and it would manifestly be to the interest of the state to aid in its development in every possible way. The persons with whom I conversed on the subject were, as a rule, of the opinion that the state did not do its full duty in this respect. However, considering that it is a small country, under heavy expenses in maintaining the Government, and with but limited resources, the state has given no inconsiderable aid in this direction. It does not expend large sums in any one direction. Its policy is, on the other hand, to encourage the people by small money donations, and, by furnishing them expert assistants, to solve for themselves the problems as they appear. The experimental laboratory at Copenhagen should perhaps be named first. It is maintained wholly by the state in the interest of the industries among which dairying, of course, takes the leading position. It was in the capacity of director of this laboratory that Prof. Fjord and his many able assistants made the long series of experiments and investigations into the various phases of the dairy industry which have been so fruitful in beneficial results. Yet these investigations were made without any great cost to the state. As a rule, the large farmers throughout the country, who were interested in the results, lent their herds to these experiments with unstinted hand, free of charge. Under these conditions Prof. Fjord was able to carry on ex-

periments at several—frequently at as many as half a dozen—farms at once. He furnished the expert assistants, who had direct charge of the experiments and supervised the work, while the farmer, who owned the place where the work was carried on, as a rule paid for the labor.

The Government aids indirectly by offering premiums for the best dairy cattle at the shows. Such premiums are not, however, restricted to the dairy interest, but have in view the improvement of domestic animals of all kinds. It encourages the improvement of the dairy breeds by aiding the "bull associations," to which I have already had occasion to refer. For this purpose \$13,500 are at present divided yearly among the associations in various parts of the country. Thus, the state will pay one-third of the cost of keeping these bulls, within the limits of the sum named, provided the association conforms to specified rules. And, in order to be entitled to this aid the bull must be at least two years old, he must not be put to more than 100 cows, and he must be of approved quality and pure breed.

The state gives direct aid to a limited number of young men and women who desire to become experts in the dairy business. They will thus be sent to some approved agricultural school for a time, and later to some practical dairy of more or less renown, where they can obtain the necessary information and experience. Twenty-two pupils received state aid of this character in 1892 at a cost of only about \$1,620.

The state aids indirectly in the advancement of the dairy industry through the Royal Agricultural Society, which is supported in part by the state. This society has been of untold benefit to Danish agriculture. It was organized in 1769, and has ever since labored by the most effective means within its reach to improve agriculture and the condition of the farmer. Its membership has, as a rule, at all times been drawn from the leading men of the country, and these have contributed freely both of their substance and work to further the object for which the society was organized. Their most effective means are, perhaps, the education in agriculture of promising young men who, in turn, become leaders in the industry and influential factors in its improvement. This has been the main line of work for many years and is still continued. The society also maintains at least one expert adviser in dairying, whose counsel is available to any one who stands in need of advice. This post is at present filled by Mr. Bernhard Bóggild, who is not only a scientist but an expert in all dairy matters and an authority everywhere recognized. He is author of the book on dairying I have already mentioned, which is, perhaps, the best work on the subject in print. The society also aids in the improvement of the dairy cattle by supplementing the Government in giving prizes at shows and in aiding in the purchase of good bulls to be used by the bull associations. It aids by giving publicity to all useful information in the form of pamphlets and reports, which otherwise would not reach any considerable number of the farmers. The Royal Agricultural

Society of Denmark must thus be considered as affording important aid to the dairy industry, in which work it is assisted and encouraged by the state.

The state aids the dairy by maintaining three dairy experts as advisers to the people. Each one of these is assigned a definite territory. They are all under the direction of the minister of the interior. In all there are nine such advisers for the benefit of agriculture, but three of them have their work confined to the dairy. These gentlemen may be called by any creamery or dairy man in the district to assist in discovering faults in the butter, to give their advice in regard to methods of treatment of the cattle, and of the milk and butter, and, in short, to render every assistance in their power in aiding the dairy industry. For this service the adviser is paid by the state; but the person calling him pays a certain proportion of the traveling expenses and maintains him with board and lodging while at his place. I can perhaps give no better idea of the nature of this work than by quoting a portion of the report of one of them to the minister of the interior for the year 1891. This report is by Stats-Konsulent (State Adviser) J. Nissen-Dall, who is located in the city of Fredericia, and whose activity is confined to a portion of the southern peninsula and several of the smaller islands. He says:

I have during the time covered by this report been called upon to give assistance in the dairies of my district one hundred and forty-five times. I have given twenty-seven lectures on dairy matters. I have, by invitation, attended eight meetings of the farmers, and I have acted as judge of dairy exhibits nineteen times, most of the exhibitions being held at the experimental laboratory. I attended an exhibition of cheese at the same laboratory, and I attended three exhibitions of butter under the auspices of the dairymen's association. In conjunction with Konsulentene (advisers) Bøggild, Segelcke, and Buhl—all dairy advisers—I have visited three dairies on Funen to witness experiments in pasteurizing milk and cream. Further, I have, with pecuniary assistance from the Royal Danish Agricultural Society, visited a number of dairies where the pasteurizing of cream was being introduced, and I also made investigations in the neighborhood of Vejle. Toward the close of July, 1891, I was present at the final examination of the pupils in the Ribe Dairy School. In connection with the exhibition of butter, to be held in Göteborg (Sweden), I visited seven dairies in my district during May and June. I attended the exhibition in Göteborg, from the 3d to the 9th of August. Besides all of this I have answered a large number of questions by mail. The majority of my lectures have been held in the interest of coöperative creameries, where my subject has been The Production and Treatment of the Milk. I lectured once before the members of the Fodder Stuff Association, and once at an exhibition of cheese in Ringe.

This will give a fair idea of the nature of the work assigned to these advisers, and the results prove that the plan is thoroughly practical. This business of advising in dairy matters has become a profession in Denmark. Besides the four official advisers, one maintained by the agricultural society and three by the state, very many of the dairy associations, of which there are many throughout the country, maintain advisers of their own, and whenever a fault appears in the dairy or creamery which the man in charge is unable to remedy an adviser

is called in to investigate the cause and remedy the fault, just as a farmer here will call a veterinarian when his horse or cow gets sick, or a doctor when a member of his family gets sick. In dairies where hundreds of pounds of butter are made daily and where a deterioration in quality is sure to be followed by a decrease in price, it is of the utmost importance to remedy a defect as soon as it appears, and this is the business of the adviser.

MARKETS FOR DANISH DAIRY PRODUCTS.

Statistics published by the Government for the year 1891 show that butter was exported from Denmark to the following countries during that year, to the amounts named:

	Danish pounds.	Pounds avoirdupois.
Faroe Islands.....	17,543	19,297
Iceland.....	15,293	16,822
Greenland.....	13,618	14,980
Danish Possessions in West Indies.....	1,314	1,445
Norway.....	202,730	223,003
Sweden.....	482,950	531,245
Russia.....	623	685
To Hamburg.....	203,425	223,767
Lubeck.....	348,350	383,185
Slesvig-Holstein and Lauenburg.....	860,474	946,521
To the rest of Germany.....	10,240	11,264
To England.....	88,959,471	97,855,418
Holland.....	155,953	171,548
Belgium.....	52,726	57,998
France.....	1,211	1,332
Portugal.....	2,803	3,083
Spain.....	18,952	20,847
Italy.....	94,526	103,978
United States.....	5,500	6,050
To miscellaneous places.....	7,560	8,316
Total.....	91,455,262	100,602,784

ENGLISH IMPORTS OF DANISH BUTTER.

England, it will be noticed, is the only country which consumes Danish butter in any considerable quantity, and this is the market which they cultivate above all others. I stopped in London a few days in order to investigate this subject on the spot, and spent considerable time among the importers of Danish butter. What I learned in this regard I stated briefly in my preliminary report, and I can not do better now than to repeat what I then said, which was as follows:

All the testimony I gathered agrees in this, that the Danish butter brings the top price in the English market with one exception, and that exception is made in favor of the comparatively small amount of fresh unsalted butter shipped to London from northern France. It caters to the taste of a small but select class of consumers, and it reaches their tables inside of twelve hours from the churn. This butter, I was told, brings from one to three or four pence more per pound than the Danish butter. I tasted this butter, and to me it lacked flavor and the pleasant briskness peculiar to a fine grade of salted butter, but there is no accounting for tastes. There is a market for such butter in London, and the dairymen from northern France supply it. The Danes have tried to supply it, but their product can not reach England in less than three days, and this length of time was fatal to the rich, creamy flavor which the market demanded, and the attempt was given up.

I found also that the Danish butter finds its best market in the manufacturing towns, and that these consume relatively much more of it than the capital. This would indicate that it goes especially to the middle class and well-to-do artisans.

I inquired particularly about the manner of shipment and whether any attempt was made to keep it in a uniform temperature during transit, and I found that so far the temperature had not been controlled. It had been tried and proved that nothing was gained by it. The conditions are such that it must be handled several times, and often many times, between the dairy and its destination. It must be transferred from wagon to railway, and from railway to boat, several times, following the route of transportation from island to island to the port of shipment, and during these transfers it is often exposed for hours to a burning heat or chilling cold, which would so far affect it that no attempt to equalize the temperature where it could be controlled could remedy the damage it might already have received, while it stood in the sun on the wharf or railroad station. It is true only a very small per cent is injured from these causes, but the risk still exists. Transportation which shall be absolutely safe to the texture and flavor of the Danish butter is still an unsolved problem. Nearly all Danish butter is packed and shipped to England in small barrels, of which there are two sizes, holding, respectively, 56 and 112 pounds. This sort of package is easily handled and has become customary. The Australian and New Zealand butter is usually shipped in square boxes, holding almost 36 pounds. The French butter above mentioned is done up in 2-pound rolls and forwarded in baskets containing usually 24 pounds. To my surprise I found in several of the warehouses considerable quantities of Russian butter. Russia began to ship butter to England five or six years ago, and the amount is growing year by year. It is put up in barrels in imitation of the Danish butter.

The Danish butter maintains its high standing chiefly through its uniformity. I sampled numerous packages from various parts of the country and found them very nearly all alike. "It is all first class; it all has the same bright straw color, and the same degree of saltiness, and it varies but very slightly in aroma, flavor, and texture. Mr. Jacobsen told me that he had endeavored to secure consignments of a cheaper grade of butter, as he thought he had a market for it, but word came back that it could not be found; no inferior butter was offered for export. This uniformity in quality inspires both dealer and consumer with confidence. They know they can buy the Danish butter and be sure of getting a good article without necessitating their tasting it before they purchase. Not so, I was told, with other countries. While they might forward some very fine butter, it was never safe to depend upon it.

As to the prices which wholesale dealers in London realize on Danish butter, they rule low from an American point of view. There are fluctuations, of course, but it sells generally from 14d to 18d a pound, the latter figure being considered high.

To give an idea of the growth of the Danish export butter to England in recent years, I quote the following figures from the "Annual statement of the trade of the United Kingdom," which I procured. It is an official and entirely reliable publication:

English imports of butter from Denmark.

	*Cwts.		*Cwts.
1887	487,536	1890	824,749
1888	604,422	1891	870,211
1889	677,398	1892	863,522

Value of same in pounds sterling.

1887	2,668,694	1890	4,422,257
1888	3,334,364	1891	4,865,842
1889	3,742,860	1892	4,848,735

*Cwts. = 112 pounds avoirdupois.

I can not comment on these figures now, but they speak for themselves. At the same time the import of butter from the following countries has also increased: Sweden, Russia, Belgium, France, United States, New South Wales, New Zealand, and Canada. The greatest increase has been made by New Zealand, but still the largest import therefrom was in 1891, and amounted to only 28,647 cwts. The imports of butter from Norway, Germany, and Holland have materially decreased in this time.

STATE AID TO FOREIGN MARKETS.

To aid in the sale of Danish agricultural products in the English market, the Government detailed an official in 1888 to be permanently located in England, whose duties were to aid by all means in his power in the sale of the Danish dairy products. The office is filled by an accomplished scientist, Mr. H. Faber, who has, according to the published records, done most excellent work in the line of his appointment. To give a more complete idea of the nature of his mission I translate the following instructions to him from the minister of the interior, as published in a report from the interior department for the years 1889 and 1890, entitled "Report of the Landøkonomiske Konsulentvirksomhed:"

INSTRUCTIONS TO GOVERNMENT AGENT FABER.

(1) It will be your duty to support the good name and sale of Danish agricultural products, and particularly the dairy products on the English markets, by all the means at your disposal; and in so far as you find these means unsatisfactory, to make propositions for new and effective aids.

(2) You must direct your attention to the conditions governing trade and transportation of Danish agricultural products, and particularly the dairy products, both before they reach the English market and after they arrive there.

(3) It will be your duty to meet and correct through the press, and chiefly through the English press, all false and injurious statements concerning the Danish agriculture, and particularly our dairy industry and its products, and take the lead in setting a proper valuation on these.

(4) Your attention must be directed to frauds, both in and outside of England, which can injure the good name of Danish butter—as, for example, the misuse of Danish names, adulteration of Danish butter with oleomargarine, and the like—and make proposals for counteracting such frauds. For that purpose you must be supplied with the necessary apparatus, chemical and microscopical, to enable you to discover such adulterations.

(5) It will be your duty to keep your attention directed to the markets and ascertain if other and profitable markets can be opened for our agricultural and particularly our dairy products.

(6) When occasion demands it, and at least once a year, you must report through the Royal Danish Agricultural Society on the English market for our agricultural and especially for our dairy products, with such observations as you may see fit to make on the subject, particularly concerning the demands of the consumers, the faults and wants in our products, which should be corrected, and concerning such alterations in trade methods as may seem desirable.

(7) It will be your duty, as far as possible, to answer all inquiries directed to you, whether from Danish institutions or from men in private life concerning agriculture and the dairy. In like manner you ought to answer similar inquiries from trades-

men and consumers of Danish agricultural and dairy products in England, in so far as you may thereby serve Danish interests.

(8) You must neither directly nor indirectly allow yourself to become financially interested in the sale of Danish agricultural products or in other trade affairs.

In compliance with the above instructions, Mr. Faber took hold of his work with a vim. We learn from reports to his Government that he set about to correct false impressions concerning Danish dairying, through the press, exposed dealers who pretended to sell Danish butter, but in reality handled inferior articles from other countries. He even goes so far as to prosecute under English law those whom he can prove adulterate Danish butter or in other ways injure the trade in the genuine article. Comments are unnecessary. He renders signal service to the country in his appointed field of labor, and doubtless the increasing demand for Danish butter in England is due largely to his efforts.

RESTRICTIONS ON THE SALE OF OLEOMARGARINE.

In Denmark, as in the United States, the unrestricted sale of oleomargarine has proved to be injurious to the agricultural interests and especially to the dairy interests. To prevent this, strict laws have been enacted which regulate the manufacture and sale of this article. To quote the law, or even the chief points of it in this report, would perhaps be improper; but I will briefly note some of the leading features of the traffic and its restrictions. The law makes a distinction between "margarine" and "oleomargarine." It appears from statistics for the year, from the 1st of April, 1891, to the 1st of March, 1892, that there were in all sixteen factories where "margarine" was made and one where "oleomargarine" was made, which together produced 13,339,984 Danish pounds, for the period covered, and that there were in all 7,991 places in the country on the 31st of March, 1892, where this material was sold. This included both retail and wholesale houses. Among the chief points in the regulations concerning its sale are to be noted—

(1) The oleomargarine shall be colored light yellow. And as a standard of comparison color tables have been adopted in which different shades are numbered, the law providing that the color must not be darker than No. 9 of that scale, which is a very light straw yellow.

(2) That oleomargarine shall always be put in tubs or barrels, which must differ in shape from the ordinary packages in which butter is kept. The form adopted is an oval tub or barrel, in which the major axis shall be at least one and a half times longer than the minor axis, and the term "Margarine" shall be marked upon the ends and sides in very large letters. The accompanying illustration (Fig. 32) shows the form of the receptacle and the marking. This is not confined to large packages. All smaller vessels used to hold oleomargarine in the retail stores shall be of the same form and distinctly marked in the same manner, and all wrapping material used when purchases are wrapped up for customers shall be marked in the same manner; and, further, the per cent of butter in the mixture, if any, shall likewise be marked on the packages.

(3) All who deal in oleomargarine in any form shall procure a license from the Government before they can begin business.

(4) Three oleomargarine inspectors are appointed by the Government, each of whom has a definite district. These inspectors are charged with the duty of seeing that dealers and manufacturers comply with the law. They have authority to enter any establishment where butter is manufactured and sold and where oleomargarine is manufactured and sold, to examine the books and look into the details of the business, and they are required to take samples frequently, which are forwarded to a laboratory for analysis.

(5) The law prohibits the manufacture of butter and oleomargarine on the same premises.

These are only a few of the leading points, which, however, may serve to give an idea of the thoroughness of the control under which it is kept.

The penalties for violation of the law are severe and punishment is sure and swift. This law was first enacted in 1885, when, however, it was found to be too lenient. Later amendments have strengthened it



FIG. 33.—Required shape and marking of oleomargarine package (reduced one-half.)

on several points, and evasions of the law are now of comparatively rare occurrence, which is shown by the following statistics: From the 1st of May, 1888, to 31st of March, 1889, there were 176 convictions for violations of the law; from the 1st of April, 1889, to the 31st of March, 1890, there were 81 convictions; and from the 1st of April, 1890, to the 31st of March, 1891, there were but 36 convictions. The dairymen generally are satisfied with the workings of the law.

AGRICULTURAL AND DAIRY EDUCATION.

The two lines of education are so intimately connected that it is difficult to separate them from each other, and I therefore treat them together. There are a large number of agricultural schools and high schools in the country, nearly all of which give more or less instruction in dairy matters. I shall in the following account give a brief description of these schools, as far as I could ascertain the facts during the short time at my disposal. The institution which ranks above all others in the country is the "Royal Veterinary and Agricultural College" at Copenhagen. This is an old institution, having been in existence more than one hundred years. It was first begun as a veterinary school, and later branches in agriculture were added to it, but the veterinary branch of the institution continues to be an important one.

A law dated April 12, 1892, concerning the institution, of which I have obtained a copy, requires in its first paragraph the number of teachers in each branch to be as follows:

(1) In veterinary science, 3; (2) in agriculture, including dairying, 3; (3) in stock-breeding, 2; (4) in forestry, 2; (5) in surveying, 2; (6) in botany, 2; (7) in economic horticulture, 1; (8) in anatomy, 1; (9) in animal physiology, 1; (10) in chemistry, including agricultural chemistry, 2; (11) in physics, 1; (12) in zoölogy, 1.

This is exclusive of assistants and lecturers, for the employment of which the same law makes an appropriation of about \$8,834.50 annually. The same law puts the salary of a professor at \$864 a year, with an addition of \$162 for every five years he remains in the college. This is a relatively much higher salary than is paid to the same class of teachers in this country. The same law appropriates \$233,550 for the enlargement of the institution in nearly all of its branches, said amount to be expended in two years. In a report of the institution for 1891, which I obtained, I find the number of students given as 372. Provision is made for both long and short courses, so that it is difficult to say just what the length of the course is, but it does not exceed four years. The instruction is not free, but certain of the students are assisted by the state. Such assistance is invariably given to the best students. The dairy instruction is in charge of Prof. Segelcke, to whom I have already had occasion to refer. The teaching at the school is entirely theoretical, as far as the dairy instruction is concerned, but before a diploma is granted the student is required to spend a given time, which varies with his accomplishments, in a good dairy where the practical information can be fully supplied. The dairying is given as a part of the course in agriculture. I visited the institution and saw some of the students at work. The instruction is most thorough and confined strictly to agriculture and the related sciences. There is no literary instruction whatever given in the institution. This students are required to have before they enter.

Next to this institution comes a class of agricultural schools, some ten in number, all of which are private institutions. These, however, receive state aid in proportion to the number of students they have, the larger schools receiving each \$810 annually. At all of these schools the students pay for their instruction. In most of them the course is two years in length and confined strictly to agriculture and the related sciences. Most of them give only theoretical instruction in dairying, the practice being obtained from some first-class dairy. I will briefly mention some of these schools.

(1) *Dalum Agricultural School, per Odense*.—This is the largest of that class of institutions. It had at the time of my visit to it 107 pupils, young men of the average age of 23 years, and from all parts of the country. The course was two years in length, thoroughly practical in its nature, and included as much of the sciences related to agriculture

as the time would permit. Dairy instruction was given during the summer months. I have already had occasion to mention the farm connected with this institution.

(2) *The Olassenske Agricultural School, Næsgaard, on the Island of Falster.*—They have here but a limited number of pupils. The instruction is confined strictly to agriculture and dairying.

(3) *Lyngby Agricultural School, per Lyngby.*—There is an experiment station connected with this school maintained by the state.

(4) *Thune Agricultural School.*—This gives theoretical instruction only, and is designed to accommodate students who can spend only a short time in school. It has two courses, one of nine months and one of six months. It has 58 pupils.

(5) *Ladelund Agricultural School, per Brórub.*—This institution has some 70 students and it gives theoretical instruction in dairying, as well as in agriculture.

(6) *Malling Agricultural School.*—There are 40 students at this school. It is a well-equipped institution of high standing.

(7) *Yding Agricultural School, per Skanderborg.*

(8) *Morsó Agricultural School.*

(9) *Odense Agricultural School.*

(10) *Lyby Agricultural School.*

All of these are technical agricultural schools. But aside from them there are a large number of ordinary high schools which give agricultural instruction. It is estimated that there are about 100 of this class of institutions, many of which are most excellent. They are not classed with the agricultural schools because their main instruction is literary in its character. But, as stated, nearly all give some instruction in agriculture and dairying, and in the aggregate their influence is felt as a force in agricultural education.

Next to the schools comes the instruction received in the dairies. There are some 2,000 dairies in the country which receive pupils, and it is here that the majority of dairymen are educated. The instruction is of the most practical nature, the pupils doing any work which the business requires. As I have already had occasion to remark, these pupils usually receive their board and lodging and a very small salary besides, though in a few cases they pay for the privilege of working in the dairy. In some cases the dairy superintendent lectures to the pupils and thus, in a measure, supplies the lack of theoretical instruction, but this is the exception and not the rule.

U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF ANIMAL INDUSTRY.

BULLETIN No. 6.

ADDITIONAL INVESTIGATIONS

CONCERNING

INFECTIOUS SWINE DISEASES.

BY

THEOBALD SMITH, PH. B., M. D., AND VERANUS A. MOORE, B. S., M. D.

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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., April 21, 1894.

SIR: I have the honor to transmit herewith the manuscript of the report which contains the results of some important investigations concerning infectious swine diseases. These investigations have been carried on for several years by my assistants in the laboratory and the present report contains results not heretofore published.

Very respectfully,

D. E. SALMON,
Chief.

Hon. J. STERLING MORTON,
Secretary.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., March 31, 1894.

SIR: I have the honor to submit herewith investigations dealing mainly with problems relating to hog cholera and swine plague. They have been carried on since 1889, and have had for their object the endeavor to find out upon what factors the great diversity in the characters of infectious swine diseases depends. The problems have presented themselves in the course of the more important investigations on swine diseases already published, and a solution seemed essential to any further progress in this work. To the report is appended a brief résumé of the results obtained, together with suggestions as to future lines of work which are most likely to yield valuable results.

Respectfully,

THEOBALD SMITH,
Chief, Division of Animal Pathology.

Dr. D. E. SALMON,
Chief of Bureau of Animal Industry.

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ADDITIONAL INVESTIGATIONS CONCERNING INFECTIOUS SWINE DISEASES.

THE HOG-CHOLERA GROUP OF BACTERIA.

By THEOBALD SMITH.

Now that authorities, especially the German, have satisfied themselves that the bacteria described in former reports of the Bureau as hog-cholera and swine-plague are really distinct species belonging to different groups, and that the somewhat labored efforts to re-examine the work in this direction have come to a close, we may be permitted to examine this important group of bacteria a little more closely and report on certain variations of the hog-cholera bacillus itself as encountered in different outbreaks. The necessity for more extended studies of allied bacteria forming well-marked groups is painfully evident as we read over the now voluminous literature of bacteriology. Especially with regard to the apparently spontaneous appearance of epidemics and epizootics of infectious diseases and the interrelation of human and animal diseases, it is of the utmost importance to examine, not only bacteria actually found to produce disease, but also those which are evidently closely related to disease-producing bacteria in their morphological and biological characters.

VARIETIES OF THE HOG-CHOLERA BACILLUS.

Bacillus cholerae suis.—This microörganism was first encountered in 1885* and possessed the following characters, as determined at that time and subsequently:

Morphology.—A rod-shaped organism (bacillus) 1.2 to 1.5 μ long and 0.6 μ broad, with extremities rounded off. Spore formation not observed. It possesses the power

* Second Annual Report of the Bureau of Animal Industry (1885), p. 212. This organism was at that time called the swine-plague bacterium. The following year another organism was found in diseased swine so closely resembling the swine-plague bacterium, as described by Schütz in Germany a few months previous, that the name swine-plague was given to this second organism for the sake of uniformity of nomenclature and the old name "hog cholera" given to the bacillus described in this article. This change seems to have caused more or less misunderstanding and led to much misguided criticism.

of motion to an unusual degree. It stains readily in aniline dyes. In cover-glass preparations from the tissues of inoculated animals, the central portion of the rod is frequently only feebly stained.

Biology.—This bacillus grows fairly well on nearly all of the ordinary culture media, such as bouillon, gelatin, agar, milk, and blood serum. It thus possesses distinctly saprophytic properties. It is favored by the temperature of the blood and multiplies but feebly at 70° F. It fails to liquefy gelatin or to coagulate milk. It is destroyed in fluids at a temperature of 58° C. maintained ten to fifteen minutes.

Pathogenesis.—It produces in swine the infectious disease characterized chiefly by necrosis and ulceration of the mucous membrane of the large intestine and is occasionally accompanied by pneumonia of limited extent. It is fatal to rabbits, mice, and guinea-pigs in small doses, introduced either under the skin or into the stomach. In rabbits the disease is usually fatal in seven days when very minute doses are introduced under the skin. The period of disease may, however, be shortened *ad libitum* by employing large doses or injecting into the circulation directly.

Rabbits which have succumbed to minute doses show on post-mortem examination a small amount of suppurative infiltration at the place of inoculation. The spleen is engorged, the liver in a state of parenchymatous degeneration, and contains small foci of necrosed tissue. The kidneys are in a state of parenchymatous degeneration, the urine albuminous and containing hog-cholera bacilli. Peyer's patches may be pigmented and swollen. At the pyloric valve, the duodenum is frequently ecchymosed (probably due to discharge of bacilli in the bile). The heart muscle is markedly fatty, the lungs hyperæmic and frequently do not collapse when the thorax is opened.

More recently some additional characters have been determined which define still more narrowly its relation to other species and groups. Among these are the following:

1. The existence of a variable number of flagella. These have been specially studied in this laboratory by Dr. V. A. Moore.* He found most frequently 2 to 5, more rarely 8 or 9, flagella on a single organism. They vary in length, the more usual dimensions being from 7 to 12 μ . In one case a flagellum was found 18 μ long.

2. The fermentative action on dextrose in ordinary peptone bouillon. During the fermentation carbonic dioxide and hydrogen are evolved, and the fluid becomes markedly acid. Milk sugar and cane sugar are not attacked. Neither gases nor acids are formed in bouillon containing them.

3. A peculiar action on milk by which this fluid becomes opalescent and partly translucent.

We shall denominate the bacillus first described and subsequently encountered most frequently in outbreaks of swine disease as bacillus α and apply to the other varieties found other letters.

B. chol. suis β .—This variety was obtained from the spleen of a Nebraska pig early in 1886. It has been described in detail † in former publications and only a summary of its divergent characters is called for. One of the first things to arouse my interest was the bouillon culture. Within twenty-four to thirty-six hours after inoculation the fluid was covered by a thin, brittle, but complete membrane. The microscopic examination of such a culture showed that the bacilli in the fluid were of the same size as those of bacillus α and equally active.

* The Wilder Quarter Century Book, p. 355.

† Third Annual Report of the Bureau of Animal Industry (1886), p. 38.

In the membrane, however, the rods were evidently a trifle longer and not in motion.

There was another peculiarity observed which is of considerable interest. In making cultures on gelatin plates by drawing the platinum wire dipped in bouillon cultures rapidly across the still soft gelatin layer three or four times I observed that colonies of bacillus α appeared within due time, while those of bacillus β on the same plate refused to grow. With a low power of the microscope, very minute colonies could be detected, which grew no larger. The difficulty was found to be due to the fact that β requires a more strongly alkaline reaction of the gelatin than α . When this demand was satisfied the colonies grew even larger than those of α .

It is a curious fact that this variety, kept growing in the laboratory, mainly on agar, for over six years, still manifests these same peculiarities. It forms the membrane with the same rapidity, and unless the gelatin is distinctly alkaline* the colonies do not appear. A comparison made in December of 1892 with a number of cultures from various outbreaks showed that while colonies of all the other varieties of the hog-cholera bacillus appeared in gelatin rolls β refused to develop.

In order to make it grow sodium carbonate was added to the ordinary feebly alkaline beef-infusion-peptone gelatin and the result was quite striking, as the following notes show:

Na_2CO_3 in the form of a normal, sterilized solution was added to feebly alkaline nutrient gelatin in different quantities:

- a. To gelatin a, 0.025 per cent.
- b. To gelatin b, 0.05 per cent.
- c. To gelatin c, 0.075 per cent.

With these three sets of tubes rolls were prepared from the same bouillon culture. The first dilution was made in sterile water, the second and third in gelatin. The rolls made therefrom will be denominated *A* and *B* respectively. In *B* the colonies were few and became much larger subsequently than in the *A* roll.

4th day. a. *A* roll, colonies 0.032-0.048 mm. diameter.

b. *A* roll, colonies 0.128-0.16 mm. diameter.

c. *A* roll, colonies 0.128-0.16 mm. diameter.

13th day. a. *A* roll; colonies of all sizes, from mere specks to such as large as in *b* and *c*.

B roll; only two deep colonies, each 1 mm. diameter.

b. *B* roll; deep colonies 1-1.25 mm. diameter, surface colonies 3-3.5 mm. diameter.

c. Same as *b*.

19th day. a. *B* roll shows more colonies than before; surface colonies as large as those of *b* and *c*.

In all *B* rolls the surface colonies have formed large expansions resembling those of *B. coli*.

46th day. a. In *B* roll surface colonies have spread out in the form of thin patches 10-15 mm. diameter.

c. In *B* roll they are more restricted, 5 to 6 mm. diameter, and fleshier.

*The culture medium is made alkaline with sodium carbonate, the indicator being litmus paper. For beef-infusion-peptone gelatin about 40 cc. of the normal solution is added to each liter.

The addition of the alkaline carbonate had thus the marked effect of causing the development of the colonies of β to such an extent that they outstripped those of all hog-cholera colonies I have ever seen. In fact, the size of the surface colonies made me suspicious of some contamination until the inoculation of a rabbit with a culture made from one of these colonies, and various other tests, showed that my suspicions were unfounded.

A further peculiarity of the growth of these colonies appeared in the gelatin rolls containing the smallest quantity of alkali. The colonies did not all appear at once and continue of the same size, as is universal in plate and roll cultures, but they appeared at intervals, so that, after a time, a large number of colonies, greatly varying in size, appeared where only a few had started originally. Evidently the insufficient quantity of alkali added was responsible for this, for it did not occur in the rolls to which more alkali had been added. In these the appearance of the colonies was simultaneous, and they continued to be of uniform size.*

The pathogenic power of these bacilli, after artificial cultivation for six and a half years, was not yet destroyed, for a rabbit which received into an ear vein 0.12 cc. of a bouillon culture died in four days. The motility of this bacillus and the fermentative power in glucose bouillon were still present.

The pathogenic power of β was slightly less originally than that of α . It was fatal to mice and rabbits, but two guinea-pigs resisted inoculation. It was fatal to a pig when a large quantity of bouillon culture was fed it.†

B. chol. suis γ .—Isolated from the spleen of a pig in 1890.‡ This variety is exceedingly interesting from the fact that its pathogenic properties are no greater than those of *Bacillus coli communis*. That is, it requires fully 1 cc. of a bouillon culture, injected into an ear vein, to destroy a rabbit. It is introduced here for the reason that in morphological and biological characters it differs but slightly from α .

Morphology.—In young bouillon cultures the bacilli appear slightly larger than α , and sluggishly moving chains of several elements are common. In stained preparations the bacilli are slightly longer than those of α , measuring 1.8 to 2.5 μ . Even filaments 4 to 8 μ in length were occasionally detected after the bacilli had been cultivated several years.

Biology.—The gelatin colonies are of the very delicate, spreading type, with a marked bluish cast in transmitted light. They do not attain a greater diameter than 2 mm., and resemble closely colonies of *Bacillus typhi abdominalis*. The bouillon culture becomes very turbid and has a faint odor.

Pathogenesis.—Feeble or absent.

* Colonies varying in size are also observed on plates made from cultures which have been subjected to the action of acids arising from fermentation.

† Loc. cit., p. 43.

‡ Report on Swine plague (1891), p. 77.

B. chol. suis δ .—Isolated at the same time with bacillus γ .

Morphology.—In general like α , though the bacilli appear a trifle plumper.

Biology.—Bouillon cultures become quite turbid. In the earliest cultures the bacilli formed clumps which in the hanging drop moved about as single masses. This peculiarity maintained itself for months and after passage through several rabbits. At present it seems to have disappeared.

Pathogenesis.—Quite feeble, perhaps a degree below that of β . The bacillus seems to have no effect on pigs.*

B. chol. suis ϵ .—This variety, obtained from a Virginia outbreak in 1890, agrees entirely with α in all but two features:

The surface colonies on gelatin plates instead of having the slightly convex form of α spread out in somewhat thinner, more or less bluish patches with sharp, undulating border, in this regard approaching the nonpathogenic variety, bacillus γ . A second differential feature is the viscid condition of the colonies and of the diffuse growth on agar. When this is touched with the platinum needle a delicate thread may be drawn out several millimeters in length. This peculiarity at first led me to suspect the purity of the culture. After making repeated plate cultures and passing the culture obtained from colonies through rabbits the same viscosity reappeared. It has persisted in cultures up to the present.

B. chol. suis ζ .—This interesting variety of the hog-cholera bacillus was obtained from cases of disease early in 1889. The outbreak presented a number of characters not noted in outbreaks examined up to that date. These have been very briefly referred to in former publications.†

Morphology.—This variety differs from α in appearing a trifle larger. In attempting, however, to present this impression of the eye in figures, I found it impossible to determine any difference, probably owing to the still crude state of the present microscopic measuring apparatus. It is not uncommon to find longer filaments in the various culture media, some of which show active movements.

Biology.—This variety may in general be regarded as nearer the saprophytic stage, for it grows more vigorously than α in the various culture media.

In gelatin plates and rolls the colonies appear within forty-eight hours, and at the end of a week develop into circular, smooth, glistening discs, which are grayish white and exhibit at times faint, concentric markings. When 1 or 2 cm. apart, they may be 3 or 4 mm. in diameter. The deep colonies are brownish, finely stippled spheres and attain a diameter of 0.4 to 0.5 mm. when not crowded. They thus resemble colonies of α in form and appearance, but are much larger.

The inclined agar growth differs from that of α only with reference to several minor points. The growth on the surface is the same with both germs, while in the condensation water there is a more active multiplication of the second germ, and the water assumes a milky white appearance. In cultures of α the liquid is not milky white, as the multiplication is far less active. In alkaline bouillon and bouillon with peptone this germ develops more rapidly and abundantly than does α . The liquid becomes very turbid over night in the thermostat and on shaking it a partly granular partly flocculent deposit arises. Careful inspection shows in some cultures a very delicate, iridescent pellicle on the surface. Multiplication was also observed

* Bulletin on Swine Plague, p. 80.

† Report of the Secretary of Agriculture for 1889, pp. 75-79.

in hay infusion. This was most vigorous when the hay infusion was made slightly alkaline.

On potato the growth resembles that of α very closely; it is perhaps of a more decided pale yellow than the latter. This description applies to cultures on pieces of potato in tubes from which evaporation is excluded. On some kinds of potato the growth is very feeble, whitish, and glistening, and easily overlooked. *Bacillus* ζ seems to be less sensitive to the reaction of bouillon. An abundant growth was obtained by adding to 10 cc. of the ordinary acid bouillon (not neutralized) a drop of lactic acid; α under the same conditions multiplies very feebly. This indifference to acid media may account for the fact that in the outbreak from which this variety was obtained the stomach was frequently attacked by necrotic and diphtheritic changes.

Pathogenesis.—This bacillus differs quite markedly from α in its virulence. The difference is best demonstrated by the inoculation of rabbits. A quantity of bouillon, less than one-fourth cc., did not prove fatal when injected subcutaneously, and in some cases even larger quantities were required. An early experiment with α showed that a dilution equivalent to $\frac{1}{400000}$ cc. of a peptone bouillon culture injected subcutaneously is still capable of proving fatal to rabbits.

While this comparatively large dose was required when injected subcutaneously, it was found in subsequent vaccination experiments with this variety that an equivalent of 0.02–0.01 cc. proved fatal when injected into an ear vein. The general character of the disease as revealed at the autopsy was likewise different from that produced by α . It lasted nearly a week longer. The spleen was not enlarged; the necrotic foci were not found in the liver; there was no hemorrhage in the duodenum, but, on the other hand, a striking disease of the intestines was present. The Peyer's patches of the small intestine were very much thickened and appeared as aggregations of whitish dots. The mucous surface over these patches was not infrequently covered by a slough. In the appendix vermiformis, part or all of the solitary follicles were enlarged, whitish, nodular, occasionally ulcerated. The Peyer's patches at the ileo-cæcal valve—one in the ileum, the other in the cæcum—were, as a rule, much thickened and covered by sloughs. In several cases the mucosa of the cæcum was covered with ulcers, probably due to bacilli discharged from the ulcerating Peyer's patches and localized here. The bacilli were readily demonstrated in the form of clumps in the infiltrated Peyer's patches and in some of the internal organs. The disease might be denominated typhoid fever of rabbits.

These various lesions did not always appear together in the same animal. Sometimes the ulceration was extensive, sometimes there was only swelling and infiltration of the follicles and Peyer's patches. Sometimes the disease was unusually prolonged. In one case, in which an ear vein injection had partially failed, the animal lived thirty-two days. All the solitary and agminated follicles of the intestines were found enlarged and infiltrated. The mucosa covering the patch in the ileum at the valve was necrosed.

In all cases there was a continuous elevation of temperature, the height of which varied with the intensity of the disease process, as gauged by the dose injected.

Feeding rabbits proved negative. The following experiments show that this variety affected mice, guinea-pigs, and pigeons:

Guinea-pig.—June 1, 1889. Two guinea-pigs received subcutaneously one-fourth and three-eighths cc., respectively, of a turbid peptone bouillon culture. The first guinea-pig died June 7. The chief lesion consisted in a sanguinolent and suppurative infiltration of the inoculated thigh, extending over the scrotum upon the other thigh. In the spleen a moderate number of bacilli. The second guinea-pig died June 10. There was a large ruptured abscess in the right groin. In the abdomen Peyer's patches are inflamed and thickened, the mesenteric glands infiltrated.

Pigeon.—May 27. Four pigeons were inoculated by partly subcutaneous, partly intramuscular injections of peptone-bouillon culture liquid over one pectoral muscle. Two received one-half cc. each, two three-fourths cc. Of these but one, which had received one-half cc., died on the following day. On the inoculated side the

major portion of the pectoral muscle appears pale and necrosed. The internal organs present nothing abnormal. Bacilli present in the blood. In the other pigeons superficial sloughs formed in the pectoral muscle.

Gray mouse.—May 17. Three mice inoculated, from the same culture used for the pigeons, by subcutaneous injection of one-twelfth, one-eighth, and three-sixteenths cc., respectively. The third mouse dead next morning. The only discoverable lesion was the distension of a portion of the small intestine with a dark red mass, probably blood. The first mouse dies in about twenty-four hours with similar lesion. The second mouse was found dead on the seventh day after inoculation. The spleen was considerably enlarged and contained many bacilli. In the small intestine yellowish liquid contents. Peyer's patches appear from serosa as aggregations of blood-red dots. Culture on agar from the spleen pure.

Feeding mice.—Two mice were starved for a day, then fed with bread crumbs upon which the condensation water from the bottom of an agar culture had been poured. Both mice were sick next day and one died about noon. The spleen was very much engorged. In the small intestine a blackish, semiliquid mass (hemorrhage). No bacilli could be seen in preparations from liver and spleen. The second mouse survived this feeding as well as a second feeding attempted two weeks later. Two mice were fed in the same way a week later. Next day both were found lying on their backs, feet extended, breathing slowly and with difficulty and opening their mouths as if gasping for breath. Brought near a hot register they speedily recovered and were quite active the remainder of the day. On the seventh day both sick again and one died on the eighth day. In the slightly enlarged spleen hog-cholera bacilli were present, as demonstrated by an agar culture.

Bacillus ζ produces in swine a true hog cholera. The chief lesions are in the large intestine and in the stomach. In the outbreak in which this bacillus was encountered there was also found extensive broncho-pneumonia associated with swine-plague bacteria and lung worms. In pigs penned with those obtained from the outbreak the disease assumed a more decidedly intestinal type, the pneumonia disappearing. As the subject is of considerable importance the notes on three pigs of the original herd and of three of those infected by them are given in an appendix to this article.

The disease induced by ζ is more prolonged, more chronic than that produced by the virulent type, α . About four weeks elapsed between infection and death. The lesions of the stomach consisted of necrotic and diphtheritic changes of the mucosa usually outside of the fundus. In the large intestine the destruction of the mucosa was very extensive. The process was partly necrotic, partly exudative in character. The mucosa in the cæcum and upper colon was converted into an amorphous, whitish layer with irregular surface which I compared in the preliminary note to cork lining in appearance and texture. In the language of pathologists it would be called branny, i. e., as if bran had been sprinkled over the surface in a dense layer. Farther down the necrosis was less diffused, more localized, and now and then replaced by a true exudate, easily removed from a surface apparently but slightly altered. Large, button-shaped, neoplastic growths were encountered in one case of the original diseased herd.

The reduced virulence of bacillus ζ as compared with that of bacillus α was furthermore demonstrated by the feeding of cultures to pigs. Only softening of the feces and marked debility with loss of appetite were noticed for several days after the feeding, with the exception of one case, which proved fatal.

May 14, 1889. Pig No. 198.—Received three days ago from a farm upon which no swine diseases have existed for a number of years. Starved since yesterday morning. To-day a pint of a 4 per cent solution of crystallized sodium carbonate given to it of which only a portion is consumed. One hour later it is drenched with 400 cc., or nearly 1 pint of a bouillon culture in which bacillus ζ (derived from a colony in a gelatine roll) has multiplied for four days. The pig is not fed until next day. On the second day diarrhea sets in and the feces have a grayish color. Small quantities of a viscid yellowish mucus containing whitish flakes, are vomited occasionally. This condition persisted until death ensued quite suddenly four days after the feeding.

The autopsy was made 36 hours after death. The animal in the meantime was kept in the refrigerator. Male pig about 3½ months old. No skin lesions observed. On back of tongue near tip a group of whitish spots as of beginning necrosis. Stomach

contains about a pint of yellowish flaky fluid. Mucosa over one-half of fundus dark red, swollen, and covered by a paper-like layer of a dull color. Around the cardiac expansion of oesophagus the mucosa has a dull yellowish appearance as if superficially necrosed. In the small intestine the inflammation progresses in severity from above downwards. This inflammation is manifested by increasing hyperæmia and injection of minute vessels, and by a tumefaction of Peyer's patches. In the ileum the walls are thickened and the reddened mucosa is covered with a thin layer of a yellowish white pasty exudate containing large numbers of leucocytes. The large Peyer's patch near the valve is partly hemorrhagic. In the large intestine the mucosa is reddened in patches, the walls of the gut thickened. The follicles in the lower colon appear with a central white point. When compressed these points are shown to be openings from which a plug of creamy matter exudes.

The urine in the bladder contains a trace of albumen and a large deposit of crystals of calcic oxalate.

From the spleen, slightly augmented in size, cultures were made, but remained sterile. From the mesenteric glands gelatin roll cultures and a bouillon-peptone culture were made. In these the fed hog-cholera bacilli developed.

Taking into consideration the pathogenic action of this bacillus on swine and on the smaller animals experimented with, no one will, I think, hesitate to accept the conclusion that bacillus ζ is a true hog-cholera bacillus closely related to or even specifically identical with bacillus α and that further experimental investigations are not called for to fortify this conclusion.

Five years ago, when this organism was first isolated, the attitude of bacteriologists, especially of the Koch school, was somewhat reserved in acknowledging the possible existence of distinct varieties of the same pathogenic species. In view of this a series of experiments were carried out to determine whether rabbits could be protected from the disease induced by bacillus α after passing through the disease produced by minute nonfatal doses of bacillus β . These results are briefly sketched on p. 43. They may be summarized as follows:

1. When α was reduced in its virulence the rabbits inoculated with it frequently presented the same gross lesions produced by β .

2. When rabbits were made partially insusceptible by inoculation with attenuated cultures of α and then inoculated with a virulent culture of α the resulting disease resembled that produced by β .

3. Rabbits which survived two inoculations of β were protected from a fatal disease when inoculated with α .

B. chol. suis η .—This variety was isolated by Dr. Moore in 1891 from the organs of a pig. It has been fully described in Bulletin No. 3 of this Bureau, and the reader is referred to that publication for a detailed account of its characters. It closely resembles α in all but one particular. It is nonmotile. This variation, apparently of such great morphological significance, is scarcely reconcilable with the close relationship existing between η and α in all other respects. Possibly η is a modification of α and originated at the Experiment Station of the Bureau where the pig was kept. Between 1885 and 1890 a large number of swine succumbed to experimental hog cholera at the station and it is not improbable that a few individuals of α may have survived in the soil or the body of insusceptible pigs where they gradually lost their motility. We know that motile bacteria may lose their motility wholly or in part in artificial cultures.

OTHER BACILLI, NOT FOUND IN OUTBREAKS OF HOG CHOLERA, WHICH BELONG TO THE SAME GROUP.

*Bacillus found in a mare after abortion.**—This organism must be grouped with the true hog-cholera bacilli. The only recognizable differences were a tendency of the colonies in the earliest cultures to flow partly down the inclined agar surface, and a feebler pathogenic power than that of *Bacillus chol. suis* α .

It is obvious that these minor variations are not of sufficient importance to separate this bacillus from the hog cholera group.†

Bacillus enteriditis, Gärtner.—This organism was found in 1888 by Gärtner in Saxony under circumstances which are of sufficient importance to deserve a somewhat extended quotation:‡

A cow, suffering with diarrhea and discharging mucus, was killed and pronounced fit for food. The autopsy revealed nothing abnormal beyond reddening of the small intestine. The flesh appeared normal and was free from odor.

A young, strong workman ate 800 grams (less than 2 pounds) of this meat raw, and seasoned with pepper and salt. He became ill two hours later, with vomiting and diarrhea, and died in about thirty-five hours. The autopsy showed inflammation of the small intestine. It was reddened and distended with gas. The solitary and agminated follicles were swollen, whitish, the mucosa in places infiltrated, whitish, in others reddish; the vessels markedly injected. In the stomach the fundus was hemorrhagic.

The meat had been put on sale May 11, and up to May 18 fifty-eight persons belonging to 25 families became ill. All of these with one exception had eaten of this meat. This person, the mother of the deceased young man, may have accidentally infected herself with his discharges.

Of the 57 persons affected 12 had eaten the meat raw, 10 had eaten fried and boiled liver, 2 a dish made from the lungs, 29 had taken boiled meat and soup, and 3 soup only.

All persons who had eaten raw meat became ill, while of those who had consumed cooked meat and soup about 36 remained well. The severity of the attack was proportional to the quantity of raw meat eaten. Thus, 1½ pounds caused death in thirty-five hours, while one-fourth pound led to a disease lasting fourteen days. In case of the cooked meat and soup no such relation was noticed. The disease produced was either very slight or severe and protracted.

There was no noticeable difference observed with reference to sex and age. The disease appeared in most cases within twenty-four to thirty hours with nausea, vomiting and purging; the vomited matters were frequently bloody, the stools greenish and mucous. These symptoms were followed by severe general disturbance, such as loss of consciousness, fever, and rapid, weak pulse, associated with great prostra-

* Bulletin No. 3 of the Bureau of Animal Industry, p. 53.

†The tendency of the colonies to run is easily accounted for by an increased production of a viscid substance around the bacilli. When sufficiently insoluble it becomes visible as a capsule in some species. In certain bacteria cultivated for a long time on agar the tendency to produce this substance seems to become augmented, and a culture originally not viscid may become so after one or more years of cultivation on alkaline agar. In the variety under consideration this tendency of the colonies to run down the agar surface was transformed later into a tendency to form a slightly wrinkled membrane. At present even this feature is no longer recognizable.

‡Corresp. d. allg. ärztl. Vereins Thüringen, 1888.

tion. Recovery took place in from five days to four weeks, according to the severity of the attack. During convalescence the epidermis peeled off.

In the flesh and the organs of the diseased cow and in the spleen of the deceased person the same bacillus was found. In the description of this bacillus by Gartner no characters are recorded which separate this organism from the hog-cholera group as extended by the varieties previously described, excepting perhaps an unusually coarse granulation of the colonies on gelatin. Unfortunately, no mention is made of the action of this bacillus on milk.

The tests of this bacillus on animals showed both toxic and pathogenic action, and demonstrated the varying susceptibility of different species to this virus. Dogs and cats remained well after consuming freely of this meat. Similarly a fowl and sparrow were not affected after eating cultures of this organism. Gray and white mice fed with cultures died in from one to three days. Rabbits died after subcutaneous inoculation with particles of infected cow's flesh in from eight to twenty days. Guinea-pigs similarly treated recovered. Cultures acted in the same way.

In the inoculated animals the small intestine was usually filled with a thin, greenish-yellow fluid, and in some rabbits a glassy mucus was discharged. After intraperitoneal injection, fibrinous exudates, chiefly on the liver, were the rule. Occasionally the pleura was affected like the peritoneum. Not infrequently hemorrhages appeared, especially under the serous membrane. The local lesion was followed by very firm infiltration of the skin and subcutis, gelatinous oedema, and suppuration.

Gartner further showed that meat in which these bacteria had multiplied, and which had been subsequently boiled to sterilize it, was very toxic and when fed to guinea-pigs and mice caused death. The same was true of the bouillon made from such infected flesh. In rabbits the poison did not act when introduced into the stomach.

Karlinski* describes a case of meat-poisoning, which he refers to *B. enteriditis* as the cause. It is a custom in Herzegovina to keep on sale, under the name *suche mесо* (dried meat), large portions of the carcasses of sheep and goats dried in the sun. This meat, although exposed to dust, sun, and rain for months, and although it is tasteless and has a penetrating rancid odor, is a favored article of diet among the poorer classes.

In May, 1889, a healthy man ate, as a result of a wager, 400 grams (somewhat less than a pound) of this dried meat softened by soaking beforehand. Within two hours nausea, vomiting, and purging set in. The temperature rose, the pulse became rapid and feeble, and the abdomen painful. Later, clonic spasms of the upper extremities, cold perspiration, and slight dilatation of the pupils were noticed. The temperature remained high for five days, then recovery slowly took place. The epidermis peeled off on the neck and extremities.

Karlinski isolated *B. enteriditis* from the vomited masses and from the dejections. Intravenous injections of this bacillus in small doses into quite young goats and lambs resulted in general depression and diarrhea, followed by death in five days. Karlinski furthermore isolated this organism from several pieces of dried meat, from the intestines of several human beings, and a goat. From these encounters he draws the conclusion that *B. enteriditis* is a widely distributed organism.†

Lubarsch‡ describes a bacillus in connection with a fatal disease in a new born child, which he is inclined to consider identical with *B. enteriditis*. There is, how-

* Centralblatt f. Bakteriologie u. Parasitenkunde, VI (1889), S. 289.

† Karlinski's frequent encounter of this bacillus raises the suspicion that he may have, at least in some cases, confounded it with varieties of *B. coli communis*. Our own experience is that bacilli of the hog-cholera group are very rare and isolated with great difficulty when saprophytic forms are also present.

‡ Arch. f. pathol. Anat., CXXIII (1891), § 70.

ever, one fact stated in the printed observations which militates against this position, namely, the coagulation of milk. The results of inoculations on smaller animals are not very precise, the doses being chosen too large. Thus, the intraperitoneal injection of several cubic centimeters of a bouillon culture of the widely prevalent *B. coli communis* is likely to prove fatal in twenty-four hours. I have found 5 cc. of a culture of *B. coli* even after sterilization at 60° C. injected into the abdominal cavity of guinea pigs prove fatal within twenty-four hours in some instances.

A culture of *B. enteriditis* from Král's laboratory in Prague, Austria, was studied by the writer in 1893. The results of the examination are briefly as follows:

In gelatin rolls the surface colonies (3-10 mm. apart) were about 1 mm. in diameter on the fourth day. They appeared as slightly convex, round masses, coarsely stippled when viewed under a low power. The deep colonies on the same plate were opaque, brownish spheres 0.25 mm. in diameter. Little change took place in the rolls subsequently. In the gelatin stick culture the needle track developed into a slight growth in three days, the surface expansion was feeble.

On inclined agar a grayish, glistening smooth surface growth and opaque whitish deposit in condensation water not at all characteristic or peculiar.

Peptone bouillon became very turbid in three days. Odor feebly sour.

Milk was not coagulated.

On potato a dry, brownish-yellow growth had appeared in three or four days.

The bacilli from agar cultures are quite small and short; those from bouillon vary more or less in length and thickness. From potato they are very short, almost oval in outline.

In bouillon they are actively motile during the first few days, later on many are without motion. From an agar and a potato culture four days old they were non-motile. Their behavior towards sugars does not differ from that of the true hog-cholera bacilli.

These morphological and biological characters are practically identical with those of the hog-cholera bacillus. The inoculation of rabbits likewise confirms this relationship.

July 12, 1893. White female rabbit, weighing 2½ pounds, receives into an ear vein about 0.12 cc. of a bouillon culture twenty-four hours old.

July 16. Rabbit found dead this morning. Spleen moderately enlarged, dark, somewhat softened. Coccidiosis of gall bladder. No necrosis in liver. Kidneys pale. In appendix of cæcum a few enlarged whitish follicles. Quite a number of follicles of the lymphatic patch in cæcum near valve enlarged, whitish. Bacteria in spleen demonstrated by the microscope and in cultures.

July 12, 1893. White female rabbit, weighing 2½ pounds, receives into an ear vein 0.24 cc. of the same culture.

July 14. Dies this morning. Spleen soft, dark, moderately engorged. Kidneys hyperemic; pale striæ in base of pyramids. Lungs hyperemic. In spleen pulp a small number of bacteria resembling the hog-cholera bacillus closely. Cultures made therefrom contain this injected organism only.

The lesions of the intestines in the first rabbit resemble those produced by *B. chol. suis* β.

Bacillus typhi murium.—In October of 1890 this organism was found by Prof. Læffler, of Greifswald, as the cause of an epizootic among white mice kept for experimental purposes in cages at the Hygienic Institute. For account of the use of this bacillus in the destruction of field pests see the Annual Report of the Department of Agriculture for 1893 (p. 155). The description which Læffler gives of this bacillus cor-

responds so closely with one or the other of the varieties of the hog-cholera bacillus that a detailed repetition of his statement is not called for. The only differential characters requiring mention are the following:

Milk is stated to become distinctly acid, but to remain unchanged in appearance.

Guinea-pigs were slightly more susceptible to subcutaneous inoculation than rabbits. The latter reacted with a local abscess only. Two pigs, 4 weeks old, were fed with large quantities of bouillon. One remained well, the other died in eight days of an intestinal catarrh. Although Loeffler is inclined to regard this death as due to some other cause, our experience would incline to the belief that the feeding was responsible for it. A culture of this bacillus from Král's laboratory, examined in 1893, presented the following features:

In gelatin rolls the colonies appeared in two days. On the fourth day the surface colonies (one-third to 1 cm. apart) had expanded so as to be 3 to 4 mm. in diameter. The outline of the expansion was roundish, the margin delicately notched. The expansion was of nearly uniform thickness without central knob, the color grayish, partly translucent. In some colonies there were faint indications of concentric zones of slightly varying opacity.

The deep colonies were spheres, about 0.5 mm. diameter, brownish, without coarse markings. In rolls containing many crowded colonies, a distinct peripheral zone appeared.

The gelatin stick culture developed a slight growth in the needle track and a thin limited surface expansion.

On inclined agar, the appearance is the same as for *B. enteriditis*.

Peptone bouillon became exceedingly turbid in three or four days.

Potato culture precisely as that of *B. enteriditis*.

The bacilli in bouillon appeared as plump rods with rounded ends, some being mere ovals. From agar they appeared as small as hog-cholera bacilli.

The motion in bouillon twenty-four and seventy-two hours old was very active. All appeared to be in motion. From agar about one-third were in motion. From potato culture four days old only Brownian motion detected.

Milk was not coagulated.

The fermentative properties were identical with those of the hog-cholera bacilli.

The following experiments on animals were made:

July 15, 1893. Female rabbit, weighing 6 pounds, received subcutaneously 0.3 cc. of a bouillon culture one day old.

July 18. Temperature 104.6° F.

July 22. Temperature 102.8°. Small local abscess. Another rabbit which had received only 0.12 cc. of the same culture reacted in precisely the same way.

July 10, 1893. A rabbit received into an ear vein 0.12 cc. of a bouillon culture six hours old.

July 11. Temperature 106.4° F.

July 12. Rabbit very ill; lies flat on abdomen, with head extended on floor of cage.

July 14. Dead this morning. Spleen very dark, soft, moderately enlarged. Liver and kidneys quite pale. Lungs hyperæmic. Heart contains thick blood.

In spleen and liver many bacilli, usually in pairs and with a feebly-stained interior like hog-cholera bacilli.

Two gray mice fed with bread soaked in bouillon cultures on three separate occasions showed no signs of illness.

This bacillus, nevertheless, possesses a considerable degree of pathogenic power. In some inoculation experiments on guinea-pigs, made recently by Dr. C. F. Dawson under my directions, it was shown that while the guinea-pig withstood rather large subcutaneous doses (0.3 cc. of a bouillon culture) it was very susceptible to minute intraabdominal doses. In a more recent comparative experiment I found 0.02 cc. of a bouillon culture of *B. typhi murium* fatal within twenty hours when injected into the abdomen. The same dose of virulent hog-cholera bacilli injected in the same way proved fatal in not less than four days.

Another bacillus* recently described by Laser as causing epizootics among field mice seems to belong to this group and to be perhaps closely related to *B. typhi murium*. A culture of this organism was not accessible for examination and comparison. Laser mentions that his bacillus produces acids in litmus whey equal in quantity to that produced by Emmerich's bacillus. This fact would group this bacillus with *B. coli*, for the hog-cholera group does not produce any acid in aerobic cultures of lactose bouillon recognizable with litmus paper. Strangely enough, no statement is made concerning its behavior in milk. A further differential character consists in its taking the Gram stain.

This bacillus appears to be more promptly fatal than hog-cholera bacilli, for both a field and a white mouse died in forty-eight and thirty-six hours, respectively, after subcutaneous inoculation. Feeding destroys the same species in four to six days. Similarly some rabbits and guinea-pigs proved susceptible. Neither the degree of susceptibility of these animals nor the pathological changes found at the autopsy have been sufficiently elucidated to be available for comparison with the hog-cholera bacillus.

A possible member of this group may be the bacillus found by Loeffler in 1881 as the presumable cause of diphtheria in pigeons.†

The disease had destroyed a flock of about 20 pigeons and only one case, the last, came into Loeffler's hands. He describes the sick pigeon as sitting trembling, with ruffled feathers and half-opened beak. The corners of the mouth, the base of the tongue, and the palate were covered with yellowish deposits. The dung was semifluid. The animal took no food, but drank much water. Death occurring during the night, the autopsy next day showed in addition to the deposits in the mouth a yellowish membrane extending through the trachea into the bronchi. In the lungs there were several pneumonic foci; there was parenchymatous clouding of the liver, slight enlargement of the spleen, occasional hemorrhages under the capsule of the kidneys. The mucosa of the intestines was markedly reddened and sprinkled with hemorrhages.

* Hugo Laser, Ein neuer für Versuchsthiere pathogener Bacillus aus der Gruppe der Fretten-Schweinesenche. Centralblatt f. Bakteriologie, XI (1892), S. 184, XIII (1893), S. 643.

† Arbeiten a. d. kaiserl. Gesundheitsamt, II (1884), S. 482.

The bacilli were found in the false membranes and in groups in the liver. The description is very meager. The inoculation of white mice is in so far interesting as it led to a fatal disease closely resembling that produced by hog-cholera bacilli in gray mice. The period of disease lasted from four to eight days. The spleen became very large and the liver mottled with necrotic foci.

GENERAL CHARACTERS OF THE HOG-CHOLERA GROUP OF BACTERIA.

After having given in brief a general description of the various members of the group of hog-cholera bacilli, we will bring together in compact form the underlying characters which bind the members of this group together, and those minor differences by which they have been individually differentiated. It should be stated that the following statements are based on an extended comparative study of these varieties, cultivated at the same time under precisely the same conditions. The microscopic observations were made only on groups of cultures prepared in this way. Careful measurements of the growth of colonies on gelatin plates have also been made, but the results, although showing well-marked constant differences, were not thought of sufficient importance to be given *in extenso*.

Morphology.—In form they are closely related. They are short rods with ends rounded, not producing spores, and possessing the power of motility with one exception (η).

More closely scrutinized they exhibit, in cultures, a certain divergence in size, which it is difficult to define. Thus bacillus ζ is evidently a trifle larger than α . In the membrane formed by β on bouillon the bacilli are longer than those in the bouillon and longer than α . The nonpathogenic form γ is distinctly larger than α , and cultures contain filaments of considerable length. Again, the swine-pest bacillus and the abortion bacillus resemble α very closely morphologically. *B. typhi murium* appears a trifle larger and plumper than α , and *B. enteriditis* inclines to involution forms.

Not only is it difficult to draw a sharp line when cultures of the same age and in the same medium are examined, but it is well nigh impossible to do this when various media are used. The different varieties vary in size from one medium to another, and any differences gained by the study of cultures in the same medium may be effaced by an examination extended to several culture media. The age of the culture as expressed by the time which has elapsed since its isolation from cases of disease may and does induce certain modifications of form not readily described.

In stained cover-glass preparations from the organs of inoculated animals, more particularly the spleen of rabbits, they resemble each other very closely. They usually present a more deeply stained periphery and give the impression of a bacillus completed filled out by a feebly-stained spore. This character, which I first pointed out in 1885, when taken together with their appearance in pairs is of considerable specific value. It is not always noticed in the most virulent varieties.

All the varieties which have been studied are capable of spontaneous motion excepting bacillus η . There is, however, no valid reason beyond this for excluding the latter from this group. In fact, setting this aside, it resembles α as closely as any other variety does.

Biology.—All varieties described fail to liquefy gelatin and as a rule grow with much less vigor on gelatin than the related group of *B. coli communis*. There exist among them 3 types of growth of the surface colonies on gelatin:

1. That of the virulent form α , the variety ζ , and *B. enteriditis*, consists of slightly

convex, roundish patches, varying in size according to the variety. The margin is not wavy, but uniformly convex. The surface very finely stippled.

2. That of the virulent variety ϵ , and the nonpathogenic γ , consists of a very thin iridescent expansion having an irregularly wavy margin. The surface shows a few branching radial furrows. This type of colony resembles closely that of the typhoid bacillus.

3. The type of β and *B. typhi murium*, representing larger and coarser expansions with wavy margin simulating closely the surface colonies of *B. coli communis*.

It will be observed that these varieties do not correspond to any special degrees of virulence. In general, however, it may be said that with one exception (γ) the vigor of the surface growth is greatest with the least virulent varieties.

In bouillon the most virulent varieties (α , ϵ , η) and the abortion bacillus produce merely a moderate clouding. The less virulent varieties including the nonpathogenic form γ produce a considerable turbidity.

The reaction depends entirely on the presence or absence of muscle glucose derived from the meat from which the bouillon is prepared. If this is present the reaction becomes acid; if absent the reaction remains alkaline. The acid reaction becomes alkaline after a variable length of time, provided the quantity of sugar in the bouillon does not exceed 0.5 per cent. This change is owing to a base produced during the growth of the bacilli which slowly neutralizes the acid formed by the fermentation of the muscle glucose.*

On potato the growth is the same among the members of this group. There may be slight variations in the depth of color of the growth due to variations in the potatoes used. Now and then potatoes are encountered on which no growth appears. The surface assumes a glistening appearance but multiplication perceptible to the eye does not take place.

In milk no precipitation or coagulation of the casein occurs with any of the forms studied. There may be observed, however, if cultures remain in the thermostat at least several weeks, a gradually developing opalescence of the milk. The milk may even assume a light brownish appearance. During this prolonged stay in the thermostat the volume of the culture shrinks by evaporation and the opalescent fluid becomes quite thick but not viscid. It is markedly alkaline. The addition of acetic acid still causes precipitation of the casein. The process appears to be a kind of saponification of the fat as a result of the increasing alkalinity of the culture with age. This action of the hog-cholera bacillus was first noticed by Bunzl. Federn† and subsequently observed independently by Dr. V. A. Moore‡ in milk cultures of the nonmotile variety of *B. cholerae suis* η .

The fermentative characters of the members of this group are remarkably uniform. I have tested them all in bouillon containing dextrose, saccharose, and lactose, respectively. Their behavior in the fermentative tube may be briefly defined as follows:

In peptone bouillon containing 1 per cent dextrose, gas appears within twenty-four hours and continues to form for three or four days. During the first twenty-four hours from one-third to one-half of the entire amount is formed, and at the end of forty-eight hours fully five-sixths has collected. During the third and fourth day only insignificant amounts are formed. The gas formation thus begins promptly and subsides with equal promptness. The total quantity which collects in the closed branch of the fermentation tube is equivalent to nearly one-half the capacity of this branch. The multiplication of the bacilli is rather feeble and subsides promptly. The strongly acid reaction developed during the fermentation is responsible for the cessation of growth and the subsequent destruction of the bacteria.

The gas set free is made up of carbonic dioxide and an explosive residue, probably hydrogen. The ratio of CO_2 to the latter is approximately as 1 to 2. This ratio

* On the method of determining the presence or the absence of muscle glucose in bouillon see the Wilder Quarter Century book (1893), p. 197.

† Arch. f. Hygiene, XII (1891), p. 198.

‡ Bulletin No. 3, p. 53.

holds only for the tube used and is different when gases are not allowed to escape. The reaction of the fluid is strongly acid.

A table illustrating the formation of gas in dextrose bouillon is subjoined:

Bacilli belonging to the hog-cholera group cultivated at 98° F. in bouillon containing one-fourth per cent peptone, 2 per cent dextrose, and one-half per cent sodium chloride.*

Culture.	Quantity of gas at 98° F. set free after—					Total 70°-80° F.	CO ₂ .	Explosive re- main- der (H).	Reaction
	One day.	Two days.	Three days.	Four days.	Five days.				
<i>a</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	<i>Per ct.</i>	
Nebraska, 1889.....	17.4	41.7	54.8	60.0	57.4	54.8	38.0	62.0	Acid.
District of Columbia, 1889	24.0	48.0	54.4	56.0	54.4	50.4	30.0	70.0	Do.
<i>β</i>									
Nebraska, 1886.....	32.5	35.8	37.5	40.0	37.5	36.6	34.0	66.0	Do.
<i>γ</i>									
New Jersey, 1890.....	33.3	48.3	51.6	56.6	55.0	50.8	37.7	62.3	Do.
<i>δ</i>									
New Jersey, 1890.....	40.8	50.0	53.6	56.0	53.6	50.4	38.0	62.0	Do.
<i>ε</i>									
Virginia, 1890.....	34.7	51.3	55.6	58.2	57.4	53.9	37.0	63.0	Do.
<i>ζ</i>									
Maryland, 1889.....	43.4	48.6	50.4	52.1	50.4	46.9	37.0	63.0	Do.
Virginia, 1889.....	45.0	58.2	58.2	58.2	55.8	52.4	36.0	64.0	Do.
<i>η</i>									
Non-motile bacillus.....				33.0	37.5	36.6	26.0	74.0	Do.
Abortion in mare.....	12.1	50.0	58.2	61.7	59.1	54.7	36.5	63.5	Do.
Swine pest.....	32.8	43.4	45.0	45.0	45.0	41.8	33.3	66.6	Do.
Mouse typhus.....		46.4	48.0			50.0	35.0	65.0	Do.
<i>B. enteriditis</i>		48.8	52.0		48.8	48.8	29.5	70.5	Do.

* There is no noticeable difference between 1 and 2 per cent dextrose bouillon.

This table demonstrates the marked uniformity among the members of this group in their behavior towards dextrose bouillon. *Bacillus β* and *η* produce somewhat less than the normal quantity of gas. It should be borne in mind, however, that the culture of *β* was over six years old when this gas test was applied. As to *η* it is not so easy to explain the variation.

A further evidence of the close relationship of the members of this group is manifested in saccharose and lactose bouillon. If the bouillon is free from muscle glucose not a trace of gas appears and the reaction, as determined with litmus paper, remains unchanged, or becomes more strongly alkaline. This must be regarded as sufficient evidence that these sugars are not attacked. The absence of any power to ferment lactose thus differentiates this group sharply from the colon group, some of which act upon lactose and saccharose as well as dextrose, others upon lactose and dextrose only. In both groups the action on dextrose is the same.

In order to facilitate the comparison of a considerable number of cultures with reference to the formation of indol Kitasato's method was used. Tubes containing 10 cubic centimeters of a sterilized solution of 1 per cent peptone and 0.5 per cent common salt in distilled water were inoculated with the various members of the hog-cholera group, and placed at 37° C. for from one to three days. The growth in all tubes remained very feeble. The presence or absence of indol was determined by adding to each culture 1 cubic centimeter of a 0.02 per cent solution of potassium nitrite, freshly prepared, and about 3 small drops of concentrated, chemically-pure, sulphuric acid. As a guide a number of cultures of *B. coli communis* were treated in the same way. The color appeared slowly and was most distinct

after sixteen to twenty hours. While the cultures of *B. coli* assumed a decidedly red appearance, a few members of the hog-cholera group became feebly pink, the color of the culture of γ being the most accentuated. After a few days a decidedly carmine red deposit appeared in the cultures of *B. coli communis*. The deposit formed by the members of the hog-cholera group was whitish or feebly pinkish. This test thus gives for the colon group a different color than for the hog-cholera group. It does not discriminate distinctly between members of the latter group and varies in intensity from almost complete absence of color to a decided violet pink, in cultures of γ , the nonvirulent variety.

In general cultures of hog-cholera bacilli are free from all odor. Among the more saprophytic varieties (γ , ζ) I have detected, in bouillon cultures contained in tubes permitting but little interchange of air, a faint sour odor.

Pathogenesis.—There is considerable divergence in pathogenic power among the varieties of hog-cholera bacilli and the other members of this group. A comparison of the results obtained by inoculation into rabbits shows this very clearly. Thus Bac. α is invariably fatal in very small subcutaneous doses. The same is true of Bac. ϵ . Bac. β also was originally of nearly equal virulence. Bac. ζ was originally fatal in some cases when rather large doses, 0.2 to 0.3 cc., of a bouillon culture were injected subcutaneously.

The rest of the group are fatal only when injected into an ear vein. For this end a small quantity (0.1 cc. or less of a bouillon culture) has been usually sufficient. γ has no more pathogenic power than *B. coli communis* under like conditions. The original virulence of *B. typhi murium*, *B. enteriditis* and the swine-pest bacillus had undoubtedly been greatly reduced before they came into my hands. They were, however, still fatal to rabbits in small intravenous doses.

Besides a divergence in the degree of pathogenic power as determined by the quantity of culture fluid required to destroy rabbits there is a divergence in the nature of the pathological processes set up which is not wholly explained by a mere difference of degree.

Thus bacillus ζ produces in rabbits suppurative changes in the lymphatic apparatus of the intestines and the mesenteric glands in contradistinction to the necrotic and hemorrhagic lesions of the more virulent α . If we attempt to explain this as a mere difference of degree we are confronted by the abortion bacillus which is much less virulent than ζ , but when injected into the circulation produced marked necrotic lesions, in this respect standing nearer α . There is no doubt that with a reduction of virulence the necrotic give way in part to the suppurative processes, but this is not wholly true and we must accept subtle varieties of virulence not easily described. A marked illustration of this is the production of a peculiar pseudo-tubercular affection of the peritoneum in rabbits by a virulent hog-cholera bacillus of the α type attenuated by being contaminated with *Proteus vulgaris*.^{*} Simple loss of virulence through long cultivation on artificial media does not produce such a peculiar modification.

A number of rabbits which were examined several weeks to months after recovery from a nonfatal dose of many of the bacteria described above showed in the appendix vermiformis and more rarely in Peyer's patches at the ileo-caecal valve a few infiltrated follicles which appeared as whitish dots. This localization of the bacilli of this group in these follicles is perhaps the most constant macroscopic change to be credited to them. It appears only when the disease, after subcutaneous or intravenous inoculation, has lasted longer than a week or ten days.

In the table below an attempt has been made to bring together the minor variations among the members of this group and to omit all common characters. This table naturally suffers from the defects inherent in all tables attempting to formulate subtle differences. This is particularly true of any estimate of pathogenic activity. For a more accurate conception of this the reader is referred to the autopsy notes on rabbits in this and former publications.

^{*} See p. 88.

Variety or species.	Original source.	Morphology.	Motility.	Surface colonies on gelatine plates.	Bouillon cultures.	General character of growth.	Pathogenic power with reference to rabbits.	
							Degree as expressed in numbers.	Character.
<i>B. cholerae suis</i> α...	Swine	Involution forms usually absent.	Active.....	Small, round, slightly convex.	Moderately clouded.	Only slightly vigorous.	1	Necrotic foci in liver.
<i>B. cholerae suis</i> β...	Swine	Somewhat longer forms in bouillon membrane.	Active.....	Large, spreading like <i>B. coli</i> .	Surface membrane; growth turbid.	Vigorous; requires more alkali.	2	Necrotic foci in liver.
<i>B. cholerae suis</i> γ...	Swine	Involution forms common; slightly larger than α.	Active.....	Small, delicate colonies, resembling <i>B. typhi abdominalis</i> .	Turbid	Vigorous	Very feeble.	Like <i>B. coli</i> .
<i>B. cholerae suis</i> δ...	Swine	A trifle plumper than α.	Active.....	Like α.....	Turbid; bacilli in clumps in early cultures.	Fairly vigorous.....	4	Same as α.
<i>B. cholerae suis</i> ε...	Swine	Like α.....	Active.....	Like γ.....	Like α.....	Vainly vigorous; agar growth viscid.	1	Same as α.
<i>B. cholerae suis</i> ζ...	Swine	Slightly larger than α...	Active.....	Like α, but larger.....	Turbid	Vigorous	3	No liver necrosis; suppurative changes in Pey-er's patches, etc.
<i>B. cholerae suis</i> η...	Swine	Like α.....	No motility	Same as α.....	Clouded	Like α.....	1	More speedily fatal than α.
Bacillus of abortion in mares.	Vagina of mare.	Like α.....	Motile.....	Same as α or nearly so.	Clouded	Like α.....	4	Necrosis in liver and spleen.
Swine pest.....	(Denmark)..	Like α.....	Motile.....	Same as α or nearly so.	Clouded	Like α.....	.....	Same as α.
<i>B. typhi mouton</i> Lottier.	White mice (1890).	Plumper than α.....	Motile.....	Spreading like β.....	Turbid	Vigorous.....	4	No necrosis in liver.
<i>B. enteriditis</i> Guertner.	Cow	Rather slender forms; variable.	Motile.....	Like α.....	Turbid	Vigorous	4	No necrosis in liver.

If we attempt to sum up those characters which are to circumscribe the hog-cholera group of bacteria we are at once confronted by the scarcity of common characters, as shown in the table above. Pathogenesis, though of great importance from the standpoint of pathology, is probably the last character acquired and evidently the most variable and most readily lost. If we base the unity of this group on morphological and biological characters, we are likewise met by variations in size, absence of motility, variations in the appearance of the colonies. There are, however, certain underlying characters, as expressed by the behavior of these bacteria in bouillon containing dextrose, saccharose, and lactose, which I think will serve as a very important group character, differentiating such group sharply from the colon group. I would therefore suggest that for the present all bacteria whose size approximates that of this group, which do not liquefy gelatin and whose fermentative properties are the same as those described for this group, should be ranged under it. Future investigations into the biochemical characters of these varieties or subspecies may reveal other differential characters, but the time has not yet come when such laborious work will be undertaken on a sufficiently extensive scale to be of any service in differentiating varieties and subspecies.

A question of considerable importance to which I wish to refer very briefly in conclusion is the origin of these varieties. Are, for instance, all the varieties of hog-cholera bacilli derived from one virulent form, or have they adapted themselves from a diversity of originally related saprophytic forms, such as the colon bacilli living under the similar conditions on mucous membranes, to a parasitic existence in the organs of the living animal?

Neither view is negatived by the information thus far at hand, but the second seems the more probable to the writer. A thorough discussion of this problem, so important to epizootology, is premature, and it is simply suggested to call attention to its important bearings.

TWO OUTBREAKS OF SWINE DISEASE CAUSED BY *BACILLUS CHOLERÆ* SUIIS ♀ ASSOCIATED WITH THE SWINE-PLAGUE *BACILLUS*.

The following investigations, made four years ago, are now published for the first time. Their interest centers in the fact that in both outbreaks a much less virulent variety of the hog-cholera bacillus than that usually met with was found. The disease was likewise different from the ordinary acute hog cholera in several respects. It will be noticed that in nearly all cases swine-plague bacteria were present in the diseased lungs and in the intestines. Both outbreaks are thus illustrations of a mixed infection. In these investigations the information concerning the outbreaks was gathered by Dr. Kilborne, and the writer is indebted to him for the care of the animals at the Experiment Station and the notes made during the course of the disease. The writer is responsible for the pathological and bacteriological work.

I.

The history of this outbreak, as given by the owner, points very clearly to the importation of the disease from without.

On December 15, 1888, Mr. P., living near Knowles, Md., had eight fine shoats about 3 months old, and on this day he purchased a cheap lot of pigs in the Washington markets. One of these died on the way home, two others died during the two following days, and within ten days seven had died. The last one of the new lot died, greatly emaciated, January 20, after a sickness of from three to four weeks. The original lot on the farm showed signs of disease early in January, and up to January 22 four had died. Of the remaining four two are quite sick and two apparently well. Among the symptoms noticed by the owner was a rapid falling away in flesh, while the appetite remained fairly good up to the time of death. There was a severe cough, coupled with a nasal discharge and considerable diarrhea. In the latter stages of the disease the skin of the limbs, belly, and ears became deeply reddened. The ears turned almost black and "lopped, like the ears of a dog." On the limbs and belly the skin became "scabby, like a person with smallpox."

January 22. One of the original lot (No. 1) which died last evening was examined on the place. It was very much emaciated, the skin of ears, limbs, and abdomen a deep purple, shading into black. On the limbs numerous purplish crusts or scabs, one-sixteenth to one-eighth inch in diameter. The spleen somewhat congested, the liver pale; interlobular connective tissue increased in quantity; when cut a sensation of grittiness is imparted to the hand. The kidneys are pale, the surface with a few petechiae. Lymphatic glands (with exceptions to be mentioned) in general slightly enlarged, with cortex dark colored. The lungs, stomach, and intestines were taken to the laboratory for a more careful examination.

Both lungs, with the exception of the caudal four-fifths of the principal lobes, solid, and moderately larger than the collapsed normal lung would be. The hepatization appears to be a cellular (catarrhal) plugging of the smaller bronchi and alveoli manifesting itself by a uniform mottling of the lung surface with yellowish dots. The extent of this catarrhal filling up is shown by the greater or smaller size of the yellowish dots, which in the cephalic lobes in part coalesce, so as to give the lung tissue a uniformly yellowish-gray appearance. The entire solid portion feels granular and hard. Imbedded in the normal tissue of the right principal lobe is a mass of solid tissue, as large as a hen's egg, in a more advanced state of degeneration. On section a number of sharply but irregularly outlined masses of a pale grayish-yellow appearance, evidently necrotic, make their appearance. In the left principal lobe are two small solid masses one-half inch in diameter. The pleura is not inflamed excepting over the solid mass in the right principal lobe. Here it is one-sixteenth inch thick, opaque, roughened, and wrinkled. On opening the air tubes the smaller bronchi are found very much dilated by thick purulent contents. When the latter is removed cavities appear from the size of a hemp seed to that of a bean, which are due to distention (bronchiectasis). The larger bronchi and the trachea contain a considerable amount of a dirty, muco-purulent, partly foamy liquid, through which are disseminated small whitish flakes. The mucosa is dusky, its minute vessels injected. In the caudal portion of the large bronchi and adjoining branches, numerous lung worms. Cover-glass preparations from the lung tissue show immense numbers of bacteria of several kinds.

The stomach is slightly pigmented in the fundus, and here two small superficial ulcers are found. Beyond the region of the fundus the mucosa is beset with minute papules about one-sixteenth inch across, somewhat paler than the surrounding mucosa. The small intestine is apparently intact, excepting the Peyer's patch in the ileum near the valve, which is swollen, pigmented, and has its surface pitted so as to give it a finely honeycombed appearance.

The mucosa of the large intestine is in general very much pigmented and hence quite dark in color. Throughout caecum and colon it is studded with sloughs from one-sixteenth to three-sixteenths inch in diameter, there being from five to ten to a square inch of surface. They are round, slightly projecting, convex. The projecting mass is of a dirty yellowish color and easily scraped away, as a pulpy or friable mass, exposing either a slightly raised or depressed rough surface almost white compared with the surrounding tissue. This firm mass extends only to submucosa. The mesenteric glands are slightly enlarged, bluish red; on section a reddened line can be seen under the capsule surrounding the gland tissue.

On the ventral surface of the kidneys were about fifty dark bluish spots (ecchymoses). On section the cortex pale, the medulla darkened, the minute vessels of the mucosa in the pelvis injected.

Sections of a slough from the large intestine, hardened in alcohol, examined subsequently under the microscope, showed that that portion of the tissue included in the slough failed to retain the stain. It involved the mucous crypts down to the submucous tissue. These were necrosed, although their original outline could still be faintly seen. Adhering to the surface of these and projecting slightly above the neighboring living tissue was a layer of exudate, consisting of amorphous matter not stainable. Beneath the layer of crypts the submucosa was more or less thickened by cell infiltration; the muscular coat intact.

Bacteriological examination.—From the spleen of this pig four cultures on agar were made, and in all a large number of isolated colonies appeared on the following day. These resembled hog-cholera bacilli colonies very closely. They were from one to three millimeters in diameter, according as they were crowded or scattered; pale grayish in color. In form and motility the bacilli could not be differentiated from hog-cholera bacilli. Subsequent observations showed slight difference, however, in the mode of growth in various media. That they were slightly different from bacillus α was shown by the following experiment:

January 29. From a bouillon peptone culture of this bacillus one-eighth cubic centimeter was injected subcutaneously into a rabbit. During the following three days the temperature rose 4° F. and then gradually fell to normal on the tenth day. It was killed on the fifteenth day, when fully recovered, and an abscess found in the groin extending to the abdomen and thigh and containing a rather consistent yellowish-white pus. The internal organs, including peritoneal cavity, appeared normal. Four bouillon peptone tubes were inoculated from the spleen and liver, as follows: Two received each nearly one-half of the entire spleen of the rabbit and two equally large pieces of liver tissue. One spleen and one liver culture became clouded after several days and contained the motile bacillus originally injected into the rabbit, and this only. Two remaining tubes were sterile weeks later.

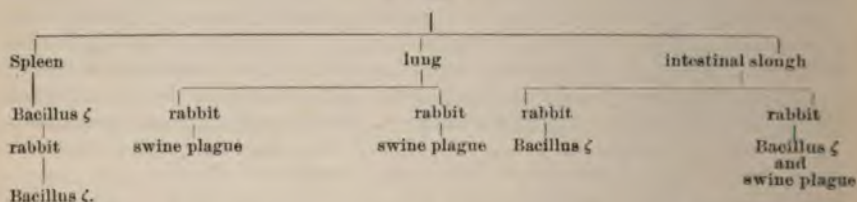
January 23. A bit of lung tissue in which the disease process appeared most recent was torn up in sterile bouillon and one-fourth cubic centimeter injected under the skin of a rabbit. Cover-glass preparations show immense numbers of bacteria of several different forms. The rabbit was found dead January 28. There was considerable suppurative thickening of the subcutis and fascia on the inoculated thigh with some ecchymosis. In the abdominal cavity a slight amount of stringy exudate on the coils of intestines and some ecchymosis on the caecum. In the blood, spleen, liver, and peritoneal exudate numerous cocci, some of which show a polar stain. Agar cultures from peritoneal exudate and blood were placed at 37° C. The blood culture on the following day contained only swine-plague bacteria, the peritoneal culture other forms also.

At the same time another rabbit was inoculated in the same way with lung tissue which was in a more advanced stage of degeneration. This rabbit died January 28. There was an extensive pasty thickening of the subcutis on both aspects of the inoculated thigh, although there was no accompanying peritonitis. From the blood a pure agar culture of swine-plague bacteria was obtained.

A piece of the ulcerated large intestine had been kept in a sterile bottle on ice since the autopsy. On January 25 a rabbit was inoculated subcutaneously by injecting one-fourth cubic centimeter of a suspension of the ulcerated tissue torn up in sterile water. This rabbit died in four days with extensive subcutaneous pasty infiltration over the inoculated thigh, and peritonitis manifested by punctiform ecchymoses under the serosa of cæcum, membranous exudate on the peritoneal covering of spleen, liver, and cæcum. These lesions are characteristic of swine plague. An agar culture from the blood developed an abundant pure growth of swine-plague bacteria, while a culture from the abdominal exudate contained both the swine-plague bacteria and hog-cholera bacilli.

On January 26 a second rabbit was inoculated in the same manner from another bit of ulcerated mucosa. It was found dead on the eighth day. The subcutis of thigh, abdomen, and thorax were very much thickened with a pasty grayish yellow infiltration and extensively discolored by blood extravasation. Peritonitis slight, perhaps caused by the very many cysts of a cysticercus attached to the omentum. Spleen but slightly enlarged. From the blood two cultures, an agar and a bouillon culture, were prepared. In both only the motile cholera bacilli appeared. The results may be tabulated as follows:

Pig No. 1.



The two pigs from this herd which were diseased were taken to the Experiment Station January 22, and placed in carefully disinfected pens. One of these died on the following day.

Autopsy.—No. 2. White male, weighing about 60 pounds, in fairly good condition. A bright scarlet blush extending along both sides of the body as a band, 3-4 inches wide, and continued on the hind limbs nearly to the feet; the same blush on both ears and under surface of jaw and neck. Along the median line on the belly there is a strip purplish in color. The urinary meatus is stained by a subcutaneous hemorrhage. On the ventral aspect of the neck are 5 to 6 scabs one-fourth inch in diameter. These adhere very firmly, and covered by them are red, depressed spots, representing the true skin.

Superficial pubic glands about 2 inches long; lobules, pale red; very œdematous, the serum amber-colored as it flows from the cut surface. On opening abdomen, a large clot was found attached to the ventral abdominal wall near the spleen, and extending down between the coils of the small intestine; spleen very large, soft, dark. It is about 14 inches long, 3 inches wide, and three-fourths inch thick. The origin of the hemorrhage could not be traced. It may have come from the enlarged, congested spleen during the journey.

The stomach filled with food; mucosa normal; the small intestine normal. In the cæcum there are four neoplastic growths, one of them on the valve. There are six more in the upper 8 inches of the colon. The remainder of the large intestine has a normal mucosa, and is filled with lumps of hard, dry feces. The neoplasms, situated on a pale otherwise intact mucosa, are worthy of some attention. They are about three-fourths inch in diameter. Some project one-half inch above the mucosa, others are flatter, resembling a low, broad-rimmed hat. Cutting vertically through one of the projecting masses, we have first, a thin, coal-black surface layer, beneath

this is a firm, pale yellow, almost leathery tissue, which forms the bulk of the projecting mass. The muscular coats beneath this are fused together, the neoplasm projecting somewhat deeper into them in the center than on the periphery. Lastly, the serous membrane under these masses thickened, discolored by old extravasations, and in some places adherent to adjacent structures.

The lungs are extensively diseased. Of the right lung the caudal tip and cephalic border of principal lobe, the ventral half of ventral and cephalic lobe are solid, and in the same condition as the lungs of pig No. 1. The surface mottling is faintly marked, owing to the pale, oedematous appearance of the diseased tissue. On the diaphragmatic surface of the principal lobe several areas of pneumonia are visible. Of the left lung the principal lobe contains a number of infiltrated lobules, the ventral lobe is entirely hepatized, its tip of a uniform grayish opaque color; the cephalic lobes contain a number of scattered hepatized lobules.

Trachea and bronchi almost occluded with molds of a pale yellow opaque mucus. The terminal portion of both bronchi contain masses of lung worms.

In three agar tubes, inoculated by dropping into them bits of spleen tissue, no growth appeared. A rabbit inoculated with one-fourth cubic centimeter of a suspension of diseased lung tissue remained well.

The second diseased pig (No. 3), brought to the station January 22, was found dead on the morning of January 30. The lesions were limited to the lungs and large intestine, as the following notes show:

No. 3. Medium sized female, white. Decided reddening of skin over the pubic region. Of the right lung the cephalic and ventral lobe solid, granular to the touch. From the surface the lung tissue appears closely set with pale-yellow, minute spots. These give the tissue its granular consistency, and probably correspond to plugged and distended air vesicles. When a section is made through this solid tissue white consistent masses can be forced out of the air tubes, which are greatly enlarged in some places. In the cephalic lobe emphysematous lobules are interspersed in the solid tissue. In the principal lobe several foci of a grayish hepatization are present, while about one-half of the azygos lobe is solid.

Of the left lung the dependent half of the cephalic and the ventral lobe and about one-sixth of the principal lobe are hepatized. In the latter the disease is scattered in lobules having their bases chiefly in the diaphragmatic surface of the lobe.

Trachea and bronchi in part occluded with a very viscid, opaque, whitish mucus mixed with foam, and containing fragments of lung worms.

Both sides of the heart contain large clots, dark in the center, pale outside where they touch endocardium, with branches extending into the large vessels.

Kidneys very pale. Liver gritty to the knife. The parenchyma softer than normal. Lymphatic glands in general swollen and slightly reddened.

The disease in the digestive tract is confined to the large intestine. The ileo-cæcal valve has its mucosa completely replaced by a layer of a homogeneous, cheese-like, rather firm material, whitish, the surface stained yellow. In the cæcum and succeeding 8 inches of colon are 8 roundish sloughs from one-fourth to one inch in diameter, of the same nature. Lower down in the colon are ulcers from one-eighth to one-fourth inch in diameter, about 6 to a square inch. Many of these are made up of an elevation or tumefaction of the mucosa about the size of a split pea, in the center of which is a depression filled with yellowish matter. Subsequent microscopic examination of these ulcers hardened in alcohol showed that they represented the solitary lymph follicles, swollen and ulcerated. Near the valve the large Peyer's patch presented the same appearance of ulcerated follicles in sections. The mucosa was everywhere of a dark, bluish-red color.

Bacteriological examination of the diseased lung tissue showed that the cheesy masses plugging the air tubes, which seemed to be made up exclusively of pus corpuscles, contained a large number of bacteria of different forms. A rabbit inoculated from some of the lung tissue torn up and suspended in sterile water did not become ill.

A rabbit which received an injection of a suspension, in sterile water, of a small portion of ulcerated tissue from the large intestine, died in three days from swine plague. At the place of inoculation the infiltration was slight. In the abdomen slight fibrinous exudation, hemorrhages under serosa of cæcum and rectum. Spleen congested. In the abdominal exudate, in the spleen and blood numerous bacteria, showing the polar strain well in cover-glass preparations from the blood. Agar cultures from spleen and blood contain an active vegetation of this germ on the following day.

The spleen of this pig, scarcely enlarged, showed no germs on cover-glass preparations. But three agar and one bouillon-peptone culture, made by adding bits of spleen tissue contained each on the following day an active growth of bacillus ζ . In two agar tubes the colonies were isolated in the upper part of the inclined layer, and from these cultures were made into other tubes.

From one of these second bouillon-peptone cultures a rabbit received into the thigh subcutaneously one-eighth cubic centimeter, February 1. The temperature of this rabbit on the following day was 104.2; on the 4th to the 8th, inclusive, it was 105.7, 106.8, 106.8, 104.5, and 102.6, respectively. The rabbit was killed two weeks after inoculation when evidently in good health. An abscess was found in the groin filled with partly curdy, partly putty-like pus. About one-third of the spleen dropped into each of the two bouillon peptone tubes. After several days both became clouded and contained only the motile bacillus injected into the rabbit. The following table summarizes the results:

Pig No. 3.

lung	spleen	intestinal slough
rabbit	Bacillus ζ	rabbit
(negative)		swine-plague bacteria

January 22. No. 121. A pig about three and one-half months old was placed in the pen with the preceding cases. One of these, it should be borne in mind, died January 23, the other January 30. Hence this animal came in contact with diseased animals as well as an infected pen. No. 121 was very much emaciated after three weeks' exposure; its respiration was labored and accompanied by a groan; its back arched, flanks drawn in. The emaciation and weakness grew, and it died February 17, nearly one month after exposure. In the meantime several other fresh pigs had been added, and these attacked the carcass during the night and consumed part of the left lung and the heart. The autopsy made next morning revealed the following lesions:

Several hemorrhagic spots on abdomen; superficial sloughing of skin in patches on the sides of the thorax and abdomen. Also a number of scabs or crusts from one-eighth to one-quarter inch in diameter in the same situation, similar to those found on the other pigs. The spleen is barely changed in size and consistency. The lymphatics in abdomen small, slightly reddened, and pigmented. The serosa of large intestine of a more opaque white in patches and diffusely stained indicative of disease within the tube. Kidneys and liver apparently normal.

In the stomach the pyloric half of the mucosa of greater curvature is quite deeply congested. The small intestine is normal, the large intestine very severely diseased, however. Contents have the color and consistency of pea soup. The mucous layer of the entire cæcum and valve, with the exception of a small area in the blind end, is converted into a tough, yellowish-white, homogeneous layer, the free surface of which is very irregular. Its appearance might be compared to the roughness produced by cork lining, or by sprinkling small irregular fragments thickly over a surface. The entire thickness of the changed mucosa is about one-eighth inch,

firmly bound to the muscular coat which appears as a dark red oedematous layer on section. The serosa is thickened and discolored.

Below the cæcum the necrosis breaks up into roundish ulcers gradually thinning out. There are about three to four to a square inch for the first 18 inches below ileo-cæcal valve. These ulcers are roundish, with a central plug of amorphous friable, orange-colored substance, very rough on the surface, surrounded by a border of a paler-yellow necrotic material. When the slough or exudate (whatever it may have been at the start) is scraped away, a white patch appears which represents the inflammatory infiltrate, partly necrosed, partly neoplastic, extending to the muscular coats. The greater part of the mucosa not destroyed by these sloughs is covered by thin, yellowish patches, not easily scraped away. When this is attempted the membrane beneath is pale and roughened. What remains of the membrane not covered by ulcerations and exudate is of a dark slate color.

The remaining 2 feet of colon has its mucosa entirely covered by a yellow, leathery, rather smooth diphtheritic membrane about one-sixteenth inch thick. When scraped away the membrane still adheres. The muscular coats are thickened, oedematous and redder than normal on section. The meso-colic glands are enlarged, the cortex pigmented.

The lungs are the seat of broncho-pneumonia. As already stated, the left ventral and cephalic lobe had been eaten by pigs in the same pen. The remaining principal lobe is oedematous, somewhat hypostatic. The dependent or free half of the right ventral and all of the cephalic lobe is solid, barely larger than in the collapsed normal condition. The pneumonia is identical with that found in the preceding cases, i. e., catarrhal plugging of air tubes, distention of alveoli by cell exudates, and hardening of the same, the peculiar surface-mottling with small, yellowish dots, being the result. The tip of the ventral lobe is covered with a thin sheet of grayish, fibrinous exudate. The cut ends of the small air tubes exude on pressure cylindrical curdy plugs, some of these showing on their surface the impress of the minute longitudinal folds of the mucous membrane. Through these two lobes are also disseminated about 12 necrotic foci, from one-eighth to one-half inch in diameter, consisting of greenish-gray homogeneous, rather firm caseous masses. The right principal lobe oedematous. The bronchi appear normal except in the diseased lobes. Here the membrane is bluish and, on pressure, the mouths of the branches exude a thick, yellowish fluid.

Microscopic examination.—Sections of the mucosa of the large intestine overlaid by the uniform pale-yellowish diphtheritic layer showed some very interesting characters. On the mucosa was an amorphous layer which failed to retain the stain (alkaline methylene blue) excepting along the free border where a line of blue was resolved into masses of saprophytic bacteria growing on the surface of the dead tissue. This exudative layer, about one-eighth millimeter thick, rested upon the mucosa proper, deprived of its epithelium, and at certain places the process of destruction had invaded the membrane as far as the fundus of the tubules, of which the outlines could barely be distinguished and which remained unstained. The sub-mucous layer was considerably thickened by the infiltration of large numbers of leucocytes.

Careful examination under a high power showed that wherever the destructive process dipped down into the membrane itself, and in a section one-half inch long, this occurred five to six times; there a definite bacillus could be found. This bacillus pervaded the necrotic area and extended to the submucosa in large numbers. Wherever only the fundus of the tubules was intact, it was completely filled up by these bacilli forming large clumps of long, intertwining filaments. They were the only germs seen to extend into the normal tissue. Although appearing as long filaments, closer inspection revealed shorter forms, usually in pairs, each of which contained a paler central portion. The measurement of these long filaments diving

in and out of the tissue, and their resolution into segments was quite difficult. The short forms measured about 1.2 to 1.5 μ in length, and 0.5 to 0.6 μ in width.

Sections prepared from the deep circular sloughs show an unstainable necrotic mass extending almost to the muscular layers in the center and growing more and more shallow towards the periphery of the ulcer. Underlying the necrotic mass and extending a short distance from the slough is a zone of densely packed leucocytes causing a great thickening of the submucous tissue. In this ulcer neither the deeper layers of the slough nor the surrounding inflammatory zone contained bacteria.

Bacteriological examination.—From the spleen cultures on agar, in bouillon peptone, and in Esmarch tubes (gelatin) were made. In all the motile cholera bacillus ζ appeared, and in the bouillon tube also a streptococcus. The former must have been quite numerous in the spleen tissue, judging from the number of colonies in the roll cultures.

In order to test its pathogenic nature, a rabbit was inoculated February 20 by rubbing with a platinum loop some agar growth of this germ into the subcutis of abdomen. On the seventh day the temperature had risen to 105°, then it slowly fell back, reaching the normal on the fourteenth day. An abscess was forming meanwhile, which broke on the eighth day while taking the rabbit's temperature, and discharged pus freely. The rabbit was killed on the fifteenth day. Besides the abscess already noted, there was some enlargement of the spleen, but no germs were found in it on microscopic examination. The inoculated germ was still present in the spleen, however, for two bouillon peptone tubes, into each of which about one-third of the spleen was dropped, became clouded in forty-eight hours, with this and none other germ.

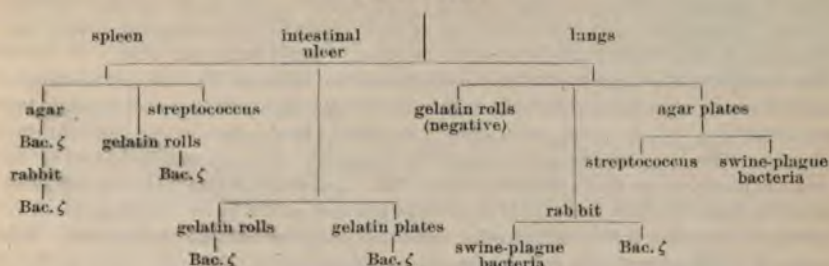
From a bit of diseased lung tissue four roll cultures are made in gelatin. The lung tissue had shown many bacteria not of one kind under the microscope. The first became completely liquefied; the others contained but a few colonies. One of these represents a micrococcus, another a slender motile bacillus. At the same time agar plates were made from the lung tissue. From these were isolated a large coccus, a streptococcus, and swine-plague bacteria.

At the same time a bit of diseased lung tissue was placed beneath the skin of a rabbit on the abdomen. It died in four days. There was extensive suppurative thickening and sanguinolent infiltration of subcutis of abdomen. Slight adhesion of caecum to abdominal wall, with ecchymoses. Spleen small. In blood a few polar-stained bacteria found. In subcutis they were also seen amongst other forms. From culture of the blood and spleen several germs were obtained; one resembling swine plague, a second the hog-cholera bacillus, and a third nonmotile oval microbe. In order to identify the swine-plague germ in one of the impure agar tubes from the blood, a little of the swine-plague growth was placed under the skin of a second rabbit. Its temperature rose to 106.6° F. on the third day. On the seventh day it had fallen to 99.2° and it was found dead next morning. The lesions were those of swine plague. There was the local subcutaneous infiltration, whitish, pasty. The inoculation over the lowest ribs had caused extensive exudative pleuritis and pericarditis, the exudate being of a creamy consistency, covering the greater part of the lung tissue of right side, less extensive on left (inoculated) side. On the epicardium a similar deposit. Agar and bouillon peptone cultures from the spleen, blood, and pleural exudate made. All but that from the spleen fertile with swine-plague bacteria.

From the diphtheritic mucosa of the large intestine of the pig gelatin roll and plate cultures were made. That portion of the mucosa most recently diseased was taken, thoroughly washed by pouring sterile water over it and material from the scraped membrane taken. Of the gelatin roll cultures one became entirely the other partially liquefied. But there were a sufficient number of nonliquefying colonies intact to make cultures in different media. When developed they all contained the hog-cholera bacilli. On the plates there were very many nonliquefying among

a few liquefying colonies. Subsequent examination with the microscope and in cultures showed that they represented hog-cholera bacteria. The following table summarizes the bacteriological examination:

Pig No. 121.



Two fresh pigs (Nos. 126 and 128) about four months old, in excellent condition, were placed in the same pen February 12, to keep up the disease for further study.

No. 128 became emaciated within a week after the transfer and continued to grow feebler until March 5, when it was found dead. There were no distinctive symptoms excepting the wasting away.

Unfortunately the lungs had been entirely eaten out during the night by the other pigs in the pen, so that we have no knowledge of their condition. The spleen was but slightly swollen. In the liver there was stasis of bile in the larger ducts owing to plugging with ascarides which had forced their way up into the liver for some distance. The kidneys apparently normal.

The stomach is normal and filled with food; duodenum and jejunum, slightly congested, contain much yellow liquid. The mucosa of lower ileum, however, is very much reddened, and the smallest vessels visible to the naked eye distinctly injected. The gross lesions of the disease are limited to the large intestine. The mucosa is in a condition identical with that of No. 121. The entire cæcum involved. On section the mucosa is seen to be replaced by a dry, caseous, yellowish-white homogeneous layer, one-sixteenth inch thick, firmly bound to muscular coat. The free surface is very rough, yellowish, resembling the cork lining already mentioned. Below the ileo-cæcal valve about one-half of the membrane is involved, the caseous layer appearing in islands which are one-half to three-fourths inch square, easily scraped away as amorphous crumbling matter and leaving a decided depression. In the lower colon the deposit is less extensive and leaves scarcely any depression when scraped away. The mucosa where still intact presents here and there groups of petechiae.

Bacteriological examination.—From the spleen of this pig cover-glass preparations were made, but the germs present were too few to be detected this way. Cultures on agar and in bouillon peptone from bits of spleen tissue contained next day bacillus ζ. To make sure, roll cultures in gelatin were made, and a rabbit inoculated from a culture derived from a colony. The illness of the rabbit was very slight. The temperature rose only to 103.8° F. on the third day, subsiding to 102.5° F. on the seventh. A small abscess had formed at the point of inoculation.

During the autopsy on the pig the bladder was ligated and removed with contents. For want of time it was kept on the ice for two days. Then the coats were burned through with a platinum spatula, several drops of clear urine added to gelatin and a roll culture made. After several days about 25 nonliquefying and several liquefying colonies appeared, the former made up of hog-cholera bacilli. Of the urine only about 10 cc. was found in the bladder. This was clear, pale-yellowish, acid, and containing much albumen. The deposit, after twenty-four hours, slight, somewhat viscid, consisting mainly of bladder epithelium.

No. 126, after being placed in the infected pen with No. 128, was found dead on the

morning of March 6, i. e., in twenty-two days. The course of the disease was precisely the same as with No. 128.

Autopsy notes.—Small black female. Behind right shoulder the skin was destroyed over an area of 3 to 4 square inches, exposing the subcutis. On the skin over the right pectoral muscle a cluster of scabs about 1 inch square. The lungs are but slightly affected. A small portion of the free end of right cephalic lobe collapsed, bluish red. A small area of collapse in right ventral, another in right principal lobe.

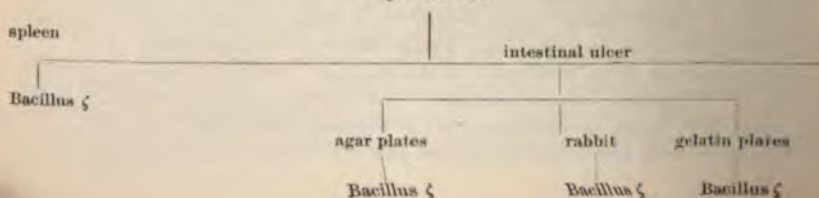
The lesions of the digestive tract closely resemble those of No. 128. The fundus of the stomach is considerably reddened. The duodenum contains several ascarides, one extending up the bile duct into the liver. The lower ileum considerably inflamed. The large intestine is extensively diseased. The mucosa is destroyed by a process identical to that observed in No. 128. Yellowish-white caseous transformation in large patches and bands in the cæcum and on the valve. Lower down in the colon exudative lesions still fresh; necrotic change of mucosa very slight. The rectum is involved as far as the anus in the same way.

Sections of the large intestine of pig No. 126 hardened in alcohol show about one-half of mucosa destroyed. Along a line half way between the base and the mouths of crypts is a densely stained line; beyond this only unstained amorphous debris attached to it, with free surface irregularly festooned. The same bacilli observed in sections of No. 121 are found dipping down in masses into the still living tissue, and wherever this dipping down occurs the tissue appears to be undergoing necrosis.

Bacteriological notes.—From the spleen of this pig the same hog-cholera bacillus was obtained pure in agar and bouillon peptone cultures, although too scarce to be detected on cover-glass preparations of spleen pulp. Its identity with the germs found in previous spleens was confirmed by its growth in gelatin roll cultures and inoculation into a rabbit. The temperature of the latter rose to 105.6° F. on the third day, but returned to 102° F. on the seventh day.

Agar plate cultures were made from a small bit of diseased intestine which was obtained as nearly as possible from the depths of the diseased membrane. From the plates the same motile germ was obtained, besides some liquefying forms. Plate cultures of gelatin were made at the same time. On these only a few liquefying colonies appeared. Of the others there were two forms, one growing on the surface as a very thin, spreading film, probably *Bac. coli communis*; the other appearing a day later and growing less vigorously, though by far the most numerous. This latter proved to be the hog-cholera bacillus. The presence of this germ was also demonstrated by the inoculation of two rabbits. A bit of the ulcerated intestine was placed beneath the skin of the thorax of each rabbit March 6. One died on the morning of March 12. The subcutaneous tissue of the whole abdomen and thorax was thickened and stained with blood, the skin was thickened and its under surface suffused with blood. The spleen slightly enlarged and congested. No peritonitis. The motile bacillus was seen in moderate numbers in cover-glass preparations and obtained in an agar culture from the spleen and the blood, about 25 to 50 colonies in each tube. A gelatine roll culture from the spleen contained a large number of one kind of colonies which were made up of the same germs. The second rabbit died next day, March 13. The lesions of the subcutaneous tissue were the same. The spleen was enlarged, dark, friable. Very slight ecchymosis and a few threads of fibrin on the cæcum. From agar and gelatin roll cultures of spleen and blood the same germ was obtained, but mixed with liquefying forms.

Pig No. 126.



II.

During September of 1889 Dr. Kilborne was directed to examine reported outbreaks of swine disease in Clarke County, Va. The disease seems to have been lingering along the river below Berryville since the previous winter, and had become especially virulent during August. It was estimated that about 75 per cent of the swine in the vicinity of Berryville succumbed to the disease. At the time of the inspector's arrival there were very few sick, many having died during the two or three weeks preceding. The symptoms observed by the owners of herds were frequent coughing, diarrhea, and occasional vomiting. The affected animals lost flesh and strength very rapidly and affections of the skin were not uncommon. Pieces were said to drop off, leaving raw, deep sores. The skin of the ears and belly became purplish and was covered with sores.

Two pigs were killed by the inspector at the time which seemed diseased. The lesions in both were confined, as far as could be determined at the time, to a broncho-pneumonia, involving in one pig nearly one-half of the lung tissue. The lungs and spleens of both animals were brought to the laboratory. Culture from the spleen of one in bouillon peptone and on agar remained clear, nor could any bacteria be detected by microscopic examination of the spleen pulp. Cultures from the spleen of the second pig developed into a pure growth of a large bacillus with terminal spore which suggested malignant œdema. Two guinea-pigs inoculated from the culture remained well.

From the lungs of these two cases bits of diseased tissue placed under the skin of two rabbits without any result. On gelatin plate cultures from them only a few miscellaneous, liquefying colonies appeared.

Two diseased pigs were sent to the Bureau Station, so that more accurate observations could be made on the nature of the disease and its communicability to healthy pigs. These observations finally showed that the disease was caused by a hog-cholera bacillus identical with bacillus 7, and that whatever the communicable power of the disease had been it was very feeble, for a pig penned with the two cases of disease passed through a mild disease only. The post-mortem notes, bacteriological observations, and inoculation experiments which led to these inferences are as follows:

Pig No. 3, received September 4, 1889, and placed in disinfected, isolated pen. Animal at this time very thin and weak. Has been sick for a week according to statement of former owner.

September 6. Failing rapidly; diarrhea; passages dark, liquid.

September 7. Animal unable to rise.

September 11. Found dead this morning, and examined at once.

Autopsy notes.—Small female; very much emaciated. Over the sternal region the epidermis peels off in large patches. One ulcer, concave, one-fourth inch in diameter on the mucous surface of right side of upper lip, covered by a thin yellowish white slough; another smaller one on left side. On the tongue 3 similar ulcers, one in top and two on right and left border.

The mucosa of the fundus of stomach is intensely hyperæmic. The pyloric portion and upper duodenum deeply bile-stained. The entire length of the ileum is beset with depressed ulcers, of ragged, irregular outline, lined with a thin slough stained yellow. These ulcers are most numerous in the uppermost and lowest portion of the ileum. In caecum and upper foot of colon there are many small ulcers. They are present on the valve as well as on the Peyer's patch near it. In the lower colon they are few but large, often one-half inch in diameter. They are found in the rectum in small numbers.

Liver apparently normal. Bile in bladder thick, full of flaky material and containing several firm lumps of a dark brownish color. Kidneys with cortex pale, dull on section. The urine in bladder contains many short, finely granular casts, and a slight amount of albumen. The spleen is but slightly enlarged.

Lungs.—Both ventral and cephalic lobes, three-fourths of median lobe, one-half of right principal lobe, and a number of scattered foci of left principal lobe, hepatized. The color varies from a bright red to a pale red, mottled with faint yellowish dots. The hepatization is firm, granular to the touch. In trachea and bronchi abundant viscid mucopus. Bronchial glands moderately enlarged, firm, of a pale pink color. Cover-glass preparations, from what appear to be the most recent diseased regions, show a large number of bacteria, resembling those of swine plague, within the protoplasm of the cells forming the exudate into the alveoli and minute air tubes.

The lymphatic glands near the stomach, in the angle of the lower jaw, those of the inguinal region beneath the skin, and under peritoneum near kidneys are all enlarged, reddened, mottled with paler spots, and with occasional petechiae. The mesenteric glands have undergone the greatest change. They are all very much enlarged, of a peculiar yellowish green color. When the peritoneal covering is torn away, they appear made up of numerous whitish follicles.

Bacteriological observations.—No bacteria were detected in the internal organs with the microscope. Cultures on agar and gelatin plates were made from the liver, mesenteric gland, and lung tissue. Agar and bouillon peptone tubes were inoculated from the spleen, mesenteric, and inguinal glands. While the plate cultures indicated the presence of but very few germs in the various organs, the agar and bouillon cultures developed quite a variety. Each organ examined contained several forms. Thus in the bouillon peptone cultures from the blood a streptococcus and a very delicate true spirillum (not a comma bacillus) developed which could not be isolated. From the lung plates the swine-plague germ was obtained besides several other forms. In the spleen tubes the swine-plague germ appeared besides other forms. From the mesenteric glands *B. coli* was obtained. No pathogenic organism was thus found in this pig save the swine-plague germ, which was itself very much attenuated. One rabbit inoculated with a bit of diseased lung tissue died in nine days. There was extensive purulent infiltration of the subcutaneous tissue, starting from the place of inoculation and extending over abdomen and thorax. In the spleen and blood, the swine-plague germ only was present. In another rabbit, inoculated from a culture of this same germ, an abscess developed at the place of inoculation. This case was thus not satisfactory in spite of the large amount of time and labor spent upon it. Probably the hog-cholera bacteria had disappeared from the body, leaving it sufficiently weakened as a prey to other bacteria whose entrance into the closed cavities was favored by the numerous ulcers in the intestines. The following case is more to the point:

Pig No. 4 received at the station at the same time (September 4). It died late September 24, and was kept in refrigerator until next morning.

Autopsy notes.—Small female, weighs about 30 pounds. The mucosa of fundus of stomach intensely hyperæmic, associated with what appears to be slight, superficial necrosis. The entire length of the ileum has its mucosa covered with a layer of exudate, stained yellow, easily removed with the fingers. It is elastic, not

readily broken up or torn, about 1 millimeter thick. In some places it adheres firmly enough to require scraping and pulling. The subjacent membrane is roughened, discolored. The walls of the intestine are much thickened. On serous aspect patches of punctiform hemorrhage. In the caecum and colon there is superficial necrosis of the mucosa. Attached to it loosely, here and there, are small, shreddy masses of exudate, stained yellow. Only one ulcer found penetrating the mucosa. The walls of the large intestine considerably thickened and oedematous. Liver firmer than normal, with scattering lobules of a deep red color. On section, a gritty sensation imparted to knife. Bile in bladder very thick, owing to the suspension of scaly masses. Evident degeneration of cortex of kidneys. The urine free from casts and albumen. Spleen moderately enlarged. In it a considerable number of embolic foci, which feel like shot.

Both lungs symmetrically diseased. The ventral lobes, the median lobe, and about one-sixth of both principal lobes (median edge) hepatized, bright red, mottled regularly with faint yellowish points. In the cephalic lobes several small areas of collapse. From the small air tubes of the hepatized lobes protrude, on pressure, semi-solid yellowish plugs of muco-pus. The larger tubes contain a more liquid secretion. In the main bronchi and trachea a small quantity of viscid muco-pus.

Bacteriological examination.—Cover-glass preparations of spleen pulp show a large number of rod-shaped bacteria, closely resembling hog-cholera bacilli in size and mode of staining. A bouillon peptone culture inoculated with spleen pulp is quite turbid on the following day and contains only motile bacilli like those found in cover-glass preparations. Two gelatin roll cultures made from a bit of spleen pulp showed within a few days an immense number of identical, nonliquefying colonies in the first tube and about 75 in the second. The latter spread on the surface of the gelatin as round disc-shaped bodies of a pearly luster reaching a diameter after one or two weeks of two to three millimeters. The gelatin was not liquefied at any time. The deep colonies are spherical, brownish by transmitted light with faintly granular disc from one half to three-fourths millimeter in diameter. In short, they appeared in all respects like *Bacillus* ζ.

In the liver, the same bacilli were found in large numbers in cover-glass preparations. A bouillon peptone and a gelatin roll culture contained the same bacilli found in spleen cultures and these only.

Gelatin roll cultures from the mesenteric glands contained colonies of the same bacilli and these only.

From the diseased lung tissue agar plates were made. These unfortunately dried out very rapidly after the first day at which date no growth was yet visible. At the same time a rabbit was inoculated by placing a bit of lung tissue under the skin. It died within thirty-six hours. The local lesion was slight and peritonitis absent. In heart's blood and spleen numerous swine-plague bacteria detected with the microscope. Cultures from these organs contain the same bacteria and these only.

Gelatin plates from diphtheritic patches of small intestine contained after a few days chiefly colonies of *B. coli*.

The hog-cholera bacilli were thus present in considerable numbers in the spleen, liver, and mesenteric glands. It was now necessary to determine whether this bacillus could produce disease, and, if so, the nature of the disease. For this purpose rabbits were used.

September 25. Rabbit received under the skin of the thigh, with a hypodermic syringe, one-quarter cubic centimeter of the bouillon culture derived from the pig's spleen. The temperature of the rabbit rose 2° to 3° F. during the week following inoculation, then gradually subsided. It was killed October 7, twelve days after inoculation, at that time apparently well. At the place of inoculation there was a small amount of purulent infiltration. The subcutaneous inoculation had thus failed, as it frequently did in case of *Bacillus* ζ from the Maryland disease. Intravenous inoculation was next tried with entire success, and any doubt as to the identity of this organism with *Bacillus* ζ thus vanished.

September 30. One-quarter cubic centimeter of a bouillon peptone culture derived from a colony in the spleen roll was injected into the ear vein of a rabbit. Its temperature on the following day 106.4° F. It was found dead October 3. The lesions consisted in a swelling of Peyer's patches and in the infiltration of the follicles in the caecum, giving them the appearance of whitish dots. The spleen was engorged and contained the injected bacilli in considerable numbers.

From a bouillon culture obtained from this rabbit two fresh rabbits were inoculated, receiving into the ear vein one-eighth and one-sixteenth cubic centimeter, respectively. In order to gauge these small quantities accurately the culture liquid was diluted. The one which had received one-sixteenth cubic centimeter died in four days. The spleen engorged, patches of necrosis in the liver. Peyer's patches pigmented, rather prominent. Urine albuminous. The injected bacilli numerous in spleen and liver. Cultures confirmatory. The rabbit which had received one-eighth cubic centimeter was dead within three days. The spleen engorged, Peyer's patches, and follicles in the caecum swollen. In the spleen numerous hog-cholera bacilli. Cultures confirmatory.

These small quantities still being sufficient to kill rabbits, one-fiftieth cubic centimeter bouillon culture derived from a spleen colony was injected into the ear vein of another rabbit October 12. It died October 17. A small number of follicles in caecum are infiltrated, enlarged, and appear as whitish elevated dots from both serous and mucous surfaces. In Peyer's patches are a few follicles similarly affected. In the liver what appears to be necrosis in small patches. Spleen moderately engorged. In spleen and liver very few bacilli.

The contagiousness of this form of hog cholera was very feeble. On September 18, six days before the second diseased pig died, a healthy pig in good condition was placed in the same pen with it. The animal, apparently well for several months, became unthrifty. Its body was covered with thick crusts when it was killed, December 9. The only discoverable evidences of infection were several cicatrices in the large intestine and one healing ulcer to which a friable slough was still attached.

EXPERIMENTS ON THE PRODUCTION OF IMMUNITY IN RABBITS AND GUINEA-PIGS WITH REFERENCE TO HOG-CHOLERA AND SWINE-PLAGUE BACTERIA.

By THEOBALD SMITH and VERANUS A. MOORE.

In the following pages are brought together a series of experiments carried on during the past four or five years. They owe their origin to various causes, first among which was the necessity of learning something of the nature of the action of hog-cholera and swine-plague bacteria in the animal body. The failure to produce immunity in swine by the injection of small doses of virulent bacteria under the skin* made further studies of the problem of immunity necessary. This study could be best prosecuted on small animals, and for this reason rabbits and guinea-pigs were chosen.

Some of the investigations were made to examine into the claim of Metchnikoff† that immunity could be easily produced in rabbits towards hog cholera by the use of blood-serum from immune rabbits. Our results had thus far been at variance with these, and proved to be totally so after repeating his work. Near the close of the investigation it was discovered that Metchnikoff had experimented with the swine-plague bacillus and not with the hog-cholera bacillus. This cleared up the difficulty. The detailed account of our observations will, without doubt, help to correct the wrong impression created by the misnaming of bacteria by Metchnikoff.

We have refrained from quoting or summarizing the now voluminous literature on the production of immunity in animals by the different processes which we have employed. The work is simply a contribution to the study of two specific pathogenic bacteria, and only those investigations are taken into consideration which deal with these bacteria. No claim is made for any new facts within the domain of immunity, excepting in so far as they apply to the disease germs experimented with.

The results obtained are, however, of special importance in shedding additional light on the divergent behavior of different species of bac-

* Report of the Bureau of Animal Industry for 1886, pp. 50-70.

† Études sur l'Immunité (5^e mémoire); immunité des lapins vaccinés contre le microbe du hog-choléra. Annales de l'Institut Pasteur, vi, 1892, p. 289.

teria acting as causes of disease, as well as the marked difference in the receptivity of different species of animals towards the same disease germ.

HOG CHOLERA.

THE PRODUCTION OF IMMUNITY IN RABBITS WITH CULTURES OF ATTENUATED HOG-CHOLERA BACILLI.

Historically, the method of using attenuated cultures to produce immunity precedes that of other methods, and we, therefore, introduce the subject by detailing some experiments made in this direction.

These were begun as far back as 1889. The method of attenuation, based on that of Pasteur in the preparation of anthrax vaccines, consisted in exposing cultures in peptone bouillon to a temperature of 43.5° to 44° C. for a variable length of time. As the bacilli die out after a time in cultures at this high temperature, a fresh tube was inoculated every ten days, placed over night in a temperature favorable to multiplication, such as 37° C., and then restored to the temperature of 43.5° to 44° C. next day. This general plan suffered occasional interruptions, owing to disturbances in the thermostat employed, sudden changes of weather, which deranged the latter, and other accidents not infrequent in experimental work. From time to time rabbits were inoculated to observe any attenuation which may have taken place. During the process of attenuation certain changes in the appearance of the cultures were noticed. There was an increased deposit of bacilli which, when shaken up, appeared in flocculi and lumps of a whitish color. The great coherence of the bacilli, together with the tendency to form a brittle surface membrane, was not observed in cultures not exposed to heat. The bacilli appeared in small clumps in the hanging drop. Their motility was but slightly impaired and the clumps moved about very vigorously. After the systematic exposure to 43.5° to 44° C. had been stopped and the culture kept by inoculation from one agar tube to another, these modifications were still observed whenever fresh bouillon was inoculated. They had therefore become more or less permanent during the long-continued process of attenuation.

With the culture thus exposed to a high temperature rabbits were inoculated from time to time. After one hundred and seventeen days of exposure, comprising about eleven reinoculations into fresh bouillon, 0.1 cc. of the culture fluid was fatal to only one-third of the rabbits inoculated subcutaneously. The same may be said of the culture after one hundred and ninety-five days. In all rabbits there was noticed, however, a rise of temperature to 104° F. or 106° F. several days after inoculation. This fever continued a variable number of days.

Without wearying the reader with any detailed account of the animals treated we may briefly summarize the preliminary results by the statement that the immunizing action was not entirely uniform. Some

treated cases died from inoculation with unattenuated cultures after a protracted illness; others fully recovered. The fact, however, was demonstrated that immunity in the very susceptible tame rabbit could be produced with cultures attenuated at a high dysgenetic temperature. The process of inducing immunity proved to be a very tedious one and checkered with many failures.

The discovery in 1889 of a distinct variety of the hog-cholera bacillus (*Bacillus* ζ, p. 13) with less pathogenic power made it desirable to determine whether rabbits could be made immune to the virulent variety after one or more inoculations with the less virulent variety. The opportunity for such a test was offered by the fact that *Bacillus* ζ was fatal to rabbits only when one-fourth of a cubic centimeter or more of a bouillon culture was injected subcutaneously. A preliminary attenuation was thus unnecessary. The method followed was to inject up to 0.2 cc. subcutaneously or from .003 cc. to .02 cc. (diluted) into an ear vein. When one or two months later the usual fatal dose of virulent hog-cholera bacilli was injected under the skin only 3 out of 8 rabbits survived. It is probable that if a second injection of the weaker variety had been made before the test inoculation the majority would have survived. This experiment thus confirmed the preceding, in establishing the fact that immunity could be produced in this way.

From these two series of experiments of 1889-'90 two rabbits were still living in 1892. They had been kept for further investigation, but other work interfered. During this interval they had successfully resisted the subcutaneous injection of the usually fatal dose of hog-cholera bacilli at two different times. The tags belonging to these rabbits had been lost, so that it was impossible to determine to which series they belonged. Their continued immunity was demonstrated by the following inoculations:

July 29, 1892. Rabbit A., large white animal, weighing 5 pounds; subcutaneous inoculation of 0.1 cc. of a virulent bouillon culture.

August 1. 107° F.

August 4. 103.9° F. Swelling one-half inch thick at seat of inoculation.

August 13. 103° F.

September 15. 102.6° F. Subcutaneous inoculation with 0.2 cc. of a virulent culture.

September 17. 103° F.

September 19. 103.2° F.

September 21. 103° F.

October 5. Intravenous injection of 0.06 cc. of a virulent bouillon culture.

October 7. 102.2° F.

This animal, supposed to have recovered entirely, died suddenly on November 8, over a month after the last inoculation. The autopsy was negative, excepting as to the brain. In the caudal portion of the right hemisphere there was a firm whitish tumor about 6 to 7 mm. in diameter. The microscopic examination of sections of hardened brain tissue revealed an abscess containing clumps of hog-cholera bacilli. The brain was examined because the person in charge of the animal room reported that the head of the rabbit had been drawn to one side one or more days before death.

July 29, 1892. Rabbit B., large yellow male; weighs 5.37 pounds. Subcutaneous injection of 0.1 cc. of a virulent bouillon culture.

August 1. 103° F.
 August 4. 102.8° F.
 August 13. 103° F.
 September 15. Subcutaneous injection of 0.2 cc. of a virulent culture.
 September 17. 103.4° F.
 September 19. 102.6° F.
 September 21. 102.8° F.

It is not improbable that the age of these two rabbits contributed, to a slight extent, to their continued powers of resistance.

From 1889 to 1892 no new work was attempted in this direction. In the latter year several things conspired to make a repetition of this work desirable. A remarkably weakened culture of the virulent hog-cholera bacillus attenuated in cultures, containing *Proteus vulgaris*, was in our possession. Metchnikoff had just published an article claiming to have readily produced immunity in rabbits by injecting the blood serum from rabbits previously immunized, by another method, against the hog-cholera bacillus. Improbable as these results seemed, they yet demanded reëxamination in the interest of some method of vaccination for swine.

Hence the attenuated hog-cholera culture was employed in the immunization of rabbits which were to furnish the blood serum to be used in repeating a portion of Metchnikoff's work.

The attempts at producing immunity were fraught with many failures, and only two rabbits were finally made insusceptible. The failures were due at first to a too rapid process of immunization, later on to a gradual return to virulence of the vaccinal culture, and to the accidents incidental to keeping animals for a long period of time. In some cases rabbits passed successfully through two inoculations, to be killed by the third, more severe test. The following is the history of the two rabbits which acquired a pretty high degree of resistance.* The details are of sufficient interest to warrant reproduction here.

White rabbit, No. 205, weight about 3 pounds at the beginning of experiment.

1. January 23, 1892. Receives a subcutaneous injection of 0.2 cc. of vaccinal culture; lesion at point of injection slight; temperature rose only to 103° F.
2. April 13. Subcutaneous injection of 0.15 cc. of same culture.
 April 18. 103.4° F.
 April 21. 103° F.
3. May 21. Intravenous injection of 0.04 cc. of same culture diluted in 10 volumes of sterile bouillon.
 May 23. 105.2° F.
 May 25. 102.8° F.
 May 27. 102.4° F.
4. June 30. Intravenous injection of 0.1 cc. of same culture.
 July 1. 106.8° F.
5. July 29. Subcutaneous injection of 0.1 cc. of a virulent bouillon culture of hog-cholera bacilli.
 August 1. 103.9° F. Seat of inoculation reddened and swollen.

* For the experiments to determine the protective power of the blood serum from these rabbits see p. 61.

- August 4. 103.8° F. Swelling as before; control rabbit dead.
 August 12. 103.6° F.
 6. September 15. Temperature 103° F; subcutaneous injection of 0.15 cc. of a virulent bouillon culture of hog-cholera bacilli.*
 September 17. 103° F.
 September 19. 102.8° F.
 September 21. 102.4° F.
 October 20. Weight, 3½ pounds.
 November 15. Weight, 4 pounds.

White male rabbit, No. 232, weighing 3 pounds.

1. February 6, 1892. Subcutaneous inoculation with 0.2 cc. of vaccinal bouillon culture.
 February 8. 102.5° F.
 February 11. 104° F.
 February 13. 106° F.
 February 15. 104° F.
 February 17. 103.4° F.
 February 18. 103.7° F.
 February 23. 103.4° F.; firm swelling about one-half inch thick at seat of inoculation.
 March 2. 102.4° F.
2. May 21. Intravenous injection of 0.04 cc. of vaccinal culture.
 May 23. 100.4° F; rabbit apparently quite ill.
 May 25. 102.4° F; rabbit better.
 May 27. 103° F.
3. June 30, intravenous injection of 0.1 cc. vaccinal culture.
 July 1. 104.2° F.
4. July 29, subcutaneous injection of 0.1 cc. of a virulent culture.
 August 1. 103.7° F; red swelling at seat of inoculation.
 August 4. 103.5° F; (control rabbit dead).
 August 13. 103.4° F.
 November 15. Weights 3½ pounds; has not gained during the process of vaccination.

These two rabbits were thus made insusceptible to a fatal subcutaneous dose of hog-cholera bacilli. No. 205 was twice tested with such a dose; No. 232 but once. The following case is interesting, for the vaccination was entirely intravenous, and the degree of immunity acquired was quite high.

No. 281, gray and white rabbit, weighing 3 pounds.

1. May 21, 1892. Intravenous injection of 0.02 cc. of the vaccinal bouillon culture, to which 10 volumes of sterile bouillon are added.
 May 25. 105° F.
 May 27. 104° F.
2. June 30. Intravenous injection of 0.06 cc. vaccinal culture.
 July 1. 106.8° F.
3. July 29. Intravenous injection repeated; some of fluid passed into subcutis of ear; probable intravenous dose 0.1 cc.
 July 30. 103.6° F.
 July 31. 104.3° F.
 August 4. 103.7° F.
 August 12. 102.8° F.

* This stock culture being in constant use and found invariably fatal a control rabbit was not inoculated at this time.

4. September 15, weighs $4\frac{3}{4}$ pounds. Intravenous injection of 0.1 cc. of vaccinal culture.

September 17, 107.3° F.

September 19, 102.8° F.

September 21, 102° F.

5. October 5, subcutaneous injection of 0.06 cc. of a virulent bouillon culture diluted with sterile water.

October 19, rabbit dies to-day. Compression of spinal cord by ulcerated lumbar vertebrae. Either result of injury or of localization of injected bacteria. Paralysis of lower extremities was noticed some days before death. Even if we assume that the disease of the vertebrae was due to the injected bacteria, which is highly improbable, the injection having been made into the subcutis, there was still a decided resistance, since death occurred from ten to twelve days later than with unprotected rabbits.

THE PRODUCTION OF IMMUNITY WITH STERILIZED BOUILLON CULTURES OF HOG-CHOLERA BACTERIA.

The culture medium employed in these experiments, with one exception, was beef infusion, containing one-half per cent peptone, one-half per cent sodium chloride and a sufficient quantity of a normal solution of sodium carbonate to give it a faintly alkaline reaction as determined by litmus paper. It was sterilized by discontinuous boiling in tubes containing 30 cc. each. After their sterility was tested the tubes of bouillon were inoculated with hog-cholera bacteria and placed in an incubator at a temperature of $35-37^{\circ}$ C. After a certain number of days (the cultures used varied in their age from five to twenty days) the cultures were exposed in a water bath to a temperature of 65° C. for two hours, after which they were returned to the incubator for from one to two days, when a tube of fresh bouillon was inoculated from each. The heated cultures were then placed in a refrigerator of about 7° C., where they were kept until used. If the freshly inoculated tubes remained clear the sterility of the heated cultures was considered assured. Before the injection of the sterilized culture fluid the quantity to be used was transferred to a sterile tube and raised to the temperature of the body.

A.—EXPERIMENTS ON GUINEA-PIGS.

The guinea-pigs used weighed from 12 to 16 ounces. They received the culture fluid subcutaneously over the abdomen. The injections were made at short intervals, usually only twenty-four hours intervening between them. To test the immunity acquired the animals were inoculated with 0.1 cc. of a fresh bouillon culture of virulent hog-cholera bacteria in from one to three days after the last injection of the sterilized liquid. In every experiment four guinea-pigs were used; two were treated and two reserved as controls.

The first experiment showed that 15 cc. of a sterilized culture, fifteen days old, injected in fourteen doses, would produce immunity. This very naturally led to the use of cultures of different ages and in smaller quantities. A question of much interest was to determine the

number of doses into which it was necessary to divide the required amount to produce a permanent resistance on the part of the animal. To this end several experiments were made, the necessary details of which are given, with the results obtained, in the subjoined table:

I.—Table showing the immunizing efficiency of sterilized bouillon cultures on guinea-pigs.

Experiments.	Guinea-pig number—	Quantity of sterilized culture fluid injected.	Number of injections.	Age of cultures when sterilized.	Time from first injection to inoculation.	Date of inoculation with living bacteria.	Control guinea-pigs died in—	Effect on treated guinea-pigs.
		c. c.		Days.	Days.		Days.	
I	1	15	14	15	18	Aug. 26, 1890	8	Recovered.
	2	15	14	15	18	...do.....	11	Do.
II ...	3	10	10	15	12	Oct. 1, 1890	8	Died in 13 days.
	4	10	10	15	12	...do.....	9	Recovered.
III ..	5	10	10	10	11	Oct. 24, 1890	6	Do.
	6	10	10	10	11	...do.....	6	Do.
IV ...	7	10	10	10	11	...do.....	6	Do.
	8	10	10	10	11	...do.....	6	Do.
V	9	10	10	20	17	Nov. 11, 1890	7	Killed Nov. 20.
	10	10	10	20	17	...do.....	7	Died in 18 days.
VI ...	11	10	10	5	17	...do.....	7	Recovered.
	12	10	10	5	17	...do.....	7	Do.
VII ..	13	10	6	10	16	Feb. 4, 1891	6	Died in 13 days.
	14	10	6	10	16	...do.....	12	Recovered.
VIII ..	15	10	4	10	16	...do.....	6	Died in 12 days.
	16	10	4	10	16	...do.....	12	Recovered.
IX ...	17	10	3	15	12	Nov. 6, 1890	12	Died in 16 days.
	18	10	3	15	12	...do.....	12	Died in 18 days.
X	19	8	8	15	11	...do.....	6	Died in 11 days.
	20	8	8	15	11	...do.....	6	Recovered.
XI ...	21	8	5	10	11	Oct. 24, 1890	6	Died in 7 days.
	22	8	5	10	11	...do.....	6	Died in 9 days.
XII *	23	† 12	6	.....	15	Feb. 4, 1891	6	Died in 6 days.
	24	† 12	6	.....	15	...do.....	12	Died in 8 days.

* Control experiment.

† Peptonized bouillon.

The immediate toxic effect produced by the subcutaneous injection of the sterilized bouillon cultures was barely observable. The liquid was rapidly absorbed, and in no case did it produce an appreciable irritation. This fact was amply illustrated by the subcutaneous injection of 13 cubic centimeters of a sterilized bouillon culture that had grown for ten days prior to its sterilization. A small guinea-pig was chloroformed and the 13 cc. injected in as many places over the body. This produced a stupefied condition which lasted several hours. The liquid was soon absorbed, leaving the subcutaneous tissue free from indurations. The guinea-pig was inoculated subsequently with 0.1 cc. of a bouillon culture of hog-cholera bacteria. It lived seven days longer than the check and exhibited a large number of tubercle-like bodies beneath the peritoncum.*

It will be observed from the table that in addition to the guinea-pigs that received 15 cc. of the culture all of those that received 10 cc. of five and ten day cultures in ten doses or injections were not seriously affected by the subsequent inoculation of hog-cholera virus. A smaller quantity of the culture fluid or a fewer number of injections were

* For a description of this modified form of the inoculation disease, see p. 87.

insufficient to produce immunity, for the inoculation with the strong virus was followed by severe local reaction and the death of a greater or less number of the animals. It is of interest to note that, as anticipated, no resistance was produced by the injection of the peptonized bouillon. (Experiment XII).

The course of the disease in the animals which had acquired a greater or less amount of resistance is exceedingly interesting. The most complete immunity was indicated by the absence of any marked reaction at the place of inoculation. The lesions of those that perished after a certain time exhibited a number of variations from those found in the checks. A slight resistance was characterized by severe local reaction and a greater resistance by certain changes in the organs. Usually a membranous exudate was found over the liver and spleen and the latter was not enlarged. The most marked peculiarity, however, was the formation of a considerable number of small, grayish, tubercle-like bodies. These were usually lenticular in form and varied from 0.25 to 2 mm. in length and from 0.1 to 1 mm. in width. They were distributed in the body as follows: Beneath the peritoneum, especially along the sides of the spinal column; beneath the pleura, more especially over the diaphragm; in the heart muscle, near the apex; and occasionally on the external surface of the abdominal wall. These bodies were firm to the touch. They consisted of a dense infiltration of round cells. Hog-cholera bacteria were present.

In the guinea-pigs which resisted for some days the spleen and liver contained very few bacteria, and frequently no bacilli could be found in cover-glass preparations from them. In similar preparations made from the tubercle-like bodies, crushed with forceps, there invariably appeared a considerable number of hog-cholera bacteria.

The disturbances noticed in the animals after their inoculation with the living bacteria and the more important lesions found upon post-mortem examination are of sufficient interest to deserve a somewhat more detailed statement. In the control animals the lesions found on post-mortem examination were, briefly stated, as follows:

At the point of inoculation a purulent infiltration into the subcutis extending over an area of from 2-4 cm. in diameter; the superficial layer of the subjacent muscle was usually discolored. Inguinal glands enlarged and reddened. Liver contained a greater or less number of necrotic foci. Spleen very much enlarged, dark-colored and friable. Peyer's patches pigmented, often swollen.

Experiment I.—Guinea-pig No. 1 developed a small swelling at the point of inoculation; otherwise both animals appeared perfectly well, and at the time the checks died they had an elevation of temperature of only about one degree. Three days later the temperature was normal. On October 1 they were reinoculated with 0.25 cc. of a bouillon culture of hog-cholera bacteria which produced a very slight local reaction. No elevation of temperature.

Experiment II.—At the time the checks died guinea-pigs Nos. 3 and 4 appeared to be well, if we except a small abscess at the point of inoculation; temperature 0.5° higher than at time of inoculation. Two days later No. 3 appeared to be sick, temperature 101° F. (Normal 102.8° F.) It was found dead on the second morning following. The post-mortem examination showed usual hog-cholera lesions with

small grayish tubercle-like bodies beneath the peritoneum on the abdominal wall. Lymphatic glands enlarged. No. 4 remained well.

Experiments III and IV.—Guinea-pigs Nos. 5, 6, 7 and 8 exhibited a slight rise in temperature on the seventh day. A cyst (about the size of a small bean) formed at the point of inoculation, which ruptured and subsequently healed. Nos. 5 and 6 lost no flesh, but Nos. 7 and 8 fell away 0.5 and 1.5 ounces, respectively.

Experiment V.—At the time the checks perished, guinea-pigs Nos. 9 and 10 appeared to be well. Two days later No. 9 was killed for examination. It exhibited a hyperæmic condition of the abdominal viscera. Lymphatic glands enlarged. In No. 10, which died on the 18th day, there was a large local ulcer, exudative peritonitis, and a large number of tubercle-like bodies lying beneath the peritoneum along the left side of the spinal column and beneath the pleura of the left lung. Considerable serum in the pleural and peritoneal cavities.

Experiment VI.—Guinea-pigs Nos. 11 and 12 suffered from severe local reaction; a cyst (containing pus) as large as a walnut formed at the point of inoculation, over which the skin sloughed. They were sick for a few days, but recovered.

Experiment VII.—At the time the check died, guinea-pigs Nos. 13 and 14 appeared to be perfectly well, if we except a slight swelling at the point of inoculation. February 14, both animals were sick. February 17, No. 13 was found dead with a small closed abscess at the point of inoculation. Beneath the peritoneum, on the abdominal walls, and especially along the left side of the spinal column, were scattered a large number of tubercle-like bodies. Lymphatic glands enlarged. Necrosis in liver. A membranous exudate over spleen and liver; spleen not enlarged or discolored. Many of the follicles in Peyer's patches infiltrated. No bacteria discovered in cover-glass preparations from spleen and liver. Covers from the tubercle-like bodies exhibited many hog-cholera bacteria. Guinea-pig No. 14 recovered.

Experiment VIII.—Guinea-pigs Nos. 15 and 16, were very sick at the time the first check died. No. 15 perished with the second check. Usual hog-cholera lesions. No. 16 lived but did not thrive.

Experiment IX.—Guinea-pigs Nos. 17 and 18 suffered from a large abscess at the point of inoculation. Spleens were enlarged and friable, otherwise they presented lesions similar to those found in guinea-pig No. 13. (Experiment VII.)

Experiment X.—Guinea-pig No. 19 exhibited severe local reaction involving subjacent muscle. Spleen not enlarged. Liver, kidneys, and small intestine hyperæmic. The cephalic lobe of right lung in a state of red hepatization. No. 20 apparently perfectly well, excepting a swelling at point of inoculation, which soon subsided.

Experiment XI.—Although the guinea-pigs resisted one and three days respectively, the lesions were practically identical with those found in the checks. Hog-cholera bacteria were found in cover-glass preparations from the spleen and liver.

Experiment XII.—One of the guinea-pigs died with the first check and one died a day before the second check perished. They showed typical hog-cholera lesions.

It is of interest to note the difference in the effect on guinea-pigs between the sterilized cultures of hog-cholera bacteria and solutions or suspensions of the poisonous substances isolated from similar cultures. A perusal of Dr. de Schweinitz's article * shows that the injection of the *sucholotoxin* and *sucholoalbumin*, which he obtained from the cultures, produced severe local reaction, followed in some cases by "ugly ulcers which healed after from ten to fourteen days." The animals appeared ill for several days after the injection, but eventually regained their normal activity. The subsequent inoculation of hog-cholera virus

* Medical News, October 4, 1890.

showed that immunity had been induced when the quantity of the toxins injected had been sufficiently large. The guinea-pigs that died after resisting the disease for a certain number of days after the controls died were examined by one of us. They showed a greater or less number of tubercle-like bodies beneath the peritoneum. Unfortunately the number of injections that were made and the quantity of culture fluid represented in the toxins used are not given, so that further comparisons can not be made.

In the spring and summer of 1893, a few similar experiments were made on guinea-pigs for the purpose of obtaining immune animals to be used in other investigations. The readiness with which guinea-pigs had been made resistant to hog cholera in 1890 led to the supposition that the same results could be obtained at any time. The following table indicates, however, that such is not the case. Although an equally virulent germ was used for making the cultures, and every particular pertaining to the previous experiment adhered to, it was with much difficulty that the necessary number of guinea-pigs were rendered immune or at least resistant to the inoculation of virulent hog-cholera bacteria. The results of these experiments are recorded in Table No. 2, appended.

II.—Table showing the immunizing effect of sterilized bouillon cultures of hog-cholera bacteria (1893).

Experiments.	Guinea-pig number—	Quantity of sterilized culture fluid injected.	Number of injections.	Age of cultures when sterilized.	Time from first injection to inoculation.	Date of inoculation with living bacteria.	Control guinea-pigs died in—	Effect on treated guinea pigs.
		cc.		Days.	Days.		Days.	
XIII	417	10	10	9	29	Jan. 22, 1893	9	Died in 13 days. Emaciated.
	418	12	12	9	29	do	9	Died in 6 days. Typical hog-cholera lesions.
XIV	419	12	12	9	29	do	9	Do.
	437	10	10	9	17	Jan. 21, 1893	9	Died in 16 days. Tubercle-like bodies beneath peritoneum.
	438	10	10	9	17	do	9	Died in 44 days. No lesions, no bacteria.
XV	439	10	10	9	17	do	9	Died in 14 days. Tubercle-like bodies beneath peritoneum.
	451	12	9	15	20	July 27, 1893	8	Died in 10 days. Typical hog-cholera lesions.
	452	12	9	11	20	do	8	Died in 11 days. Typical hog-cholera lesions.
	453	12	9	11	20	do	8	Recovered.
XIV*	454	12	9	11	20	do	8	Died in 18 days. Tubercle-like bodies beneath the peritoneum; hog-cholera bacteria.
	473	12	13	23	19	Sept. 23, 1893	6	Recovered.
	474	13	13	23	19	do	6	Do.
	475	13	13	23	19	do	6	Died in 18 days. Tubercle-like bodies beneath peritoneum and in heart muscle; hog-cholera bacteria.
	476	13	13	23	19	do	6	Died in 9 days. Typical hog-cholera lesions.
	477	13	13	23	19	do	6	Died in 10 days! Hog cholera lesions.
	478	13	13	23	19	do	6	Died in 15 days. Fatty liver, many hog-cholera bacteria.

* In this experiment bouillon containing a small quantity of dextrose was used. The bacteria were allowed to grow until the fermentation was completed and the liquid became alkaline, when a few more drops of the dextrose solution was added. This stimulated the growth of the bacteria. When used the liquid was alkaline in reaction.

† The post-mortem examination of these two animals showed that the injection had been made, accidentally, into muscular wall of abdomen.

The lesions produced in the guinea-pigs used in the second set of experiments did not differ materially from those found in the animals in the first experiments. Attention is called to the resistance maintained by guinea-pigs Nos. 437, 438, 439, 454, 475, and 478. The cause of death of No. 438 was not determined, as there were no lesions discovered and no bacteria obtained in cultures from the organs. In the other cases the lesions were characteristic of hog cholera, modified in consequence of an increased resistance on the part of the animal. It is probable that Nos. 476 and 477 would have survived if the strong virus had not been injected into the muscular tissue.

The difference in the outcome between the experiments of 1890 and 1893 can not be satisfactorily explained. It is possible that it was due to the greater susceptibility of the guinea-pigs or to some difference in the cultures. The fact should be stated, however, that the hog-cholera bacteria used were as virulent as those used in 1890. The season may have had some effect in producing the divergent results, as the experiments in 1893 were made during the heat of summer, while the very positive results of 1890 were obtained during a cooler portion of the year.

B.—EXPERIMENTS ON RABBITS.

The certainty with which guinea-pigs could be rendered immune by the use of sterilized cultures in 1890 led to a comparative test on rabbits. Experience with rabbits since 1885 in this laboratory has shown that they are invariably susceptible to hog-cholera bacteria. The experiment on guinea-pigs demonstrated the fact that the principle involved, and for the first time brought out in the pigeon experiments in 1885, was applicable to at least one species of mammals which is very susceptible to hog-cholera bacteria, and thus it answers the charge made by Chantemesse and Widal* that the experiments on pigeons proved nothing because the method failed on susceptible mammals. The experiments on rabbits about to be recorded illustrates very conclusively our inability to draw general conclusions from experiments on one species of animals.

Two small white rabbits received, each, in the subcutaneous tissue, in 11 doses, 20 cc. of sterilized bouillon cultures of hog-cholera bacteria. They were subsequently inoculated, together with two untreated rabbits, with one-eighth cubic centimeter of a bouillon culture of hog-cholera bacteria. They perished with the checks, one in six, the other in seven days after the inoculation. It is instructive to note that *no resistance* to the disease was produced, although each rabbit received one cubic centimeter of sterilized culture fluid for each $1\frac{1}{2}$ ounces of body weight, which quantity was sufficient to produce perfect immunity in guinea-pigs in 1890. The injection of the sterilized culture produced

* Annales de l'Institut Pasteur, II (1888), p. 54.

manifestly no ill effect on the rabbits. The fluid was rapidly absorbed and left no thickening of the subcutaneous tissue.

A third rabbit received 11.4 cc. of sterilized bouillon culture in the ear vein in four injections, at intervals extending over a period of twenty-four days. The first injection (3 cc.), was followed by a temperature elevation of 2° F. On the following day the temperature was above normal. The second injection, of a like quantity, was followed immediately by accelerated respiration and purging (feces blood-stained). The temperature was elevated as after the first injection. The third and fourth injections produced similar but less intense reactions. Unfortunately the rabbit was injured a few days after the fourth injection and hence chloroformed and examined very carefully, but no lesions could be detected.

A fourth rabbit, injected intravenously with 3 cc. of a similar culture, was found dead in three hours.

A fifth rabbit, received in the veins 6.25 cc. in four doses, at intervals extending over a period of thirty-four days. After each injection it exhibited symptoms similar to those already described. It became much emaciated, but otherwise appeared to be well at the time of the test. It died in five days after its inoculation with the virulent culture of hog-cholera bacilli.

EXPERIMENTS WITH STERILIZED AGAR CULTURES OF HOG-CHOLERA BACTERIA.

The agar cultures used in these experiments were prepared as follows: Large tubes (1 inch in diameter) containing 1.5 cc. of agar* were inclined, and the surface inoculated with hog-cholera bacteria. The inoculated tubes were placed in the incubator for several days when the growth on the inclined surface was washed down with sterilized beef broth and transferred by means of a flamed pipette to sterile tubes. A sufficient quantity (usually 10 cc. of sterile beef broth to the growth on four tubes of agar) of liquid was added to make a turbid suspension. When the suspension was to be injected into the veins, it was filtered through sterilized Japanese filter paper, which removed all pieces of agar that might be present. It was sterilized by an exposure to 60° C. for one hour in a water bath, after which it was returned to the incubator for one day. Its sterility was then tested by inoculating fresh tubes of bouillon. If these remained clear the death of the bacteria was considered as positive. The heated cultures were kept, until used, in a cold chamber at a temperature of from 7-9° C.

* In the preparation of the agar for this purpose, it was found that the addition of one-eighth to one-tenth per cent of white glue was beneficial in giving to the inclined agar a more firm surface from which the growth could be easily removed. The glue did not interfere with the growth of the hog-cholera bacteria, as shown by parallel cultures on ordinary agar.

A.—EXPERIMENTS ON GUINEA-PIGS.

A few experiments on guinea-pigs with sterilized agar cultures were made. The facts necessary for a full understanding of these test experiments are given in the appended table:

III.—Table showing the immunizing effect of sterilized agar cultures on guinea-pigs.

Guinea-pig number—	Quantity of sterilized agar culture injected.	Number of injections.	Time from first injection to inoculation.	Date of inoculation.	Control guinea-pigs died in—	Effect on treated guinea-pigs.
	cc.				Days.	
23	1.5	1	.....	.....	.....	Died in 20 hours after the injection.
24	1.5	1	13	June 30, 1891	6	Died in 8 days.
25	2.0	2	11	do.....	6	Died in 9 days.
26	3.5	3	11	do.....	6	Died in 15 days.
27	3.5	7	11	June 23, 1893	6	Died in 12 days.
28	3.5	7	11	do.....	6	Do.

Guinea-pig No. 23 found to be pregnant, which may explain the fatal toxic effect.

Guinea-pig No. 24 developed a large swelling where fluid was injected, which resulted in the formation of a caseous tumor. The guinea-pig was sick for several days after the injection. It resisted two days. Liver pale, contained necrotic foci. Spleen not enlarged.

Guinea-pig No. 25 exhibited a very large discolored spleen. The injection of the suspension of agar growth produced a small cyst containing a yellowish caseous substance. The local reaction of the hog-cholera virus was very slight.

Guinea-pig No. 26 was apparently perfectly well when No. 25 died, excepting a swelling about the size of a small walnut at the point of inoculation. It lived nine days after the check died. The post mortem showed a membranous exudate over liver and spleen, the latter slightly enlarged; tubercle-like bodies on the external surface of the abdominal wall and heart muscle. No hog-cholera bacteria in cover-glass preparations from the liver.

Guinea-pig No. 28 exhibited lesions which did not differ from those found in the check.

Guinea-pig No. 27 contained lesions similar to those found in No. 26.

B.—EXPERIMENTS ON RABBITS.

The rabbits used were young adults. They were kept in large wire cages during their treatment at the Experiment Station of the Bureau. The animals were somewhat carefully watched after the various injections by Dr. F. L. Kilborne, but their temperature was not taken. Usually about six days intervened between the injections. When the rabbits did not thrive a longer period was allowed to elapse between them. The results of the preliminary experiments, together with the necessary details, are given in tabulated form :

IV.—Table showing the immunizing effect of sterilized agar cultures on rabbits.

Rabbit number—	Quantity of sterilized suspension injected.	Method of injection.	Number of injections.	Age of cultures when sterilized.	Time from first injection to inoculation.	Date of inoculation with hog-cholera bacteria.	Control rabbits died in—	Effect on treated rabbits.
	cc.			Days.	Days.		Days.	
48	2.75	Ear vein.....	3	2	14	June 26, 1891	4	Died in 7 days.
49	.5	do.....	1	2	.....	.....	.....	Died a few hours after the first injection.
55	1.5	do.....	2	2	14	June 26, 1891	4	Died in 7 days.
62	2.5	do.....	3	2	.....	.....	.....	Died after third injection.
63	1.5	do.....	2	2	.....	.....	.....	Died after second injection.
64	1.5	do.....	2	2	.....	.....	.....	Do.
65	6.25	do.....	8	2	80	Sept. 9, 1891	5	Died in 6 days.
58	4.5	Abdominal cavity.	4	2	28	July 20, 1891	6	Do.
59	7.5	do.....	6	2	69	Sept. 1, 1891	6	Do.
60	11.5	do.....	8	2	78	Sept. 9, 1891	5	Do.
61	17	do.....	10	2	90	Oct. 1, 1891	6	Do.
66	6	Beneath the skin.	4	2	28	July 20, 1891	6	Died in 4 days.
67	10	do.....	6	2	69	Sept. 1, 1891	5	Died in 6 days.
68	15	do.....	8	2	88	Sept. 8, 1891	4	Died in 5 days.
69	22	do.....	10	2	98	Oct. 8, 1891	6	Do.

A glance at the table will show that the immunizing power of sterilized agar cultures on rabbits in the quantities used and according to the methods employed was *nil*. The lesions found in the rabbits that perished after the second and third injections are interesting, as they resembled somewhat those produced by the living bacteria. (See notes on Nos. 62 and 63 below.) The immediate effect of the injection was marked by depression and apparent illness. The immunity was tested by inoculating the rabbits subcutaneously with 0.05 cc. of a bouillon culture of hog-cholera bacteria (the same as used for the agar cultures) which was sufficiently virulent to destroy rabbits, in the dose given, in from five to seven days. Control rabbits were always used.*

Rabbit No. 49 died in a few hours after the first injection. The examination showed a general hyperæmic condition of the thoracic and abdominal organs. No bacteria.

Rabbits Nos. 48 and 55 showed greater local reaction than that found in the control rabbit.

Rabbit No. 62 died after the third injection of the sterilized agar culture. It had lost no appreciable amount of flesh during the treatment. The examination revealed the following conditions: Several small blood extravasations beneath the serosa in the upper colon and in the rectum. Intestines hyperæmic. In liver a large number of pale reddish areas resembling beginning necrosis. Spleen enlarged, dark colored, friable. Cortex of kidney pale, medullary portion of a bright red color. Lungs hyperæmic, partially collapsed. Heart muscle pale, sprinkled with punctiform hemorrhages. Agar tubes inoculated with pieces of the liver remained sterile.

Rabbits Nos. 63 and 64 perished after the second injection. The lesions were characterized by an enlarged spleen and liver and punctiform hemorrhages in colon and abnormally pale heart muscle. Culture media inoculated from the liver remained sterile.

* For the lesions of hog cholera in rabbits, see p. 10.

No. 65 lived one day longer than the check. It exhibited typical hog-cholera lesions.

Rabbits Nos. 58 to 61 and 66 to 69 presented lesions characteristic of hog cholera, and in no case was there any evidence of increased resistance. The lesions were practically identical with those produced in the control rabbits.

These results led to a second series of experiments on rabbits in which the immediate effect of the sterilized cultures was more carefully noted. The suspension of the agar growth was prepared, sterilized and the rabbits injected intravenously as in the preceding experiments:

V.—Table showing the intravenous injection of sterilized agar cultures of hog-cholera bacteria.

Rabbit number—	Age of culture when sterilized.	Quantity of agar suspension injected.	Number of doses.	Time from first injection to inoculation or death.	Date of inoculation with hog-cholera bacteria.	Results.
	Days.	cc.		Days.		
107	2	9.5	9	42	.....	Very poor, chloroformed for examination.
109	2	7	7	37	Oct. 10, 1891	Died with check.
113	2	1	1	4	.....	Poor, chloroformed for examination.
114	2	2	2	7	.....	Do.
123	2	6.5	3	23	Oct. 10, 1891	Died 2 days after check.
150	2	7.4	4	39	Nov. 19, 1891	Died with check in 5 days.
110	5	9.8	9	55	.....	Died October 30, emaciated and anæmic.
111	5	6.5	6	35	Oct. 10, 1891	Died October 15, with check.

The immediate effect of the sterilized suspension was very marked. Usually the rabbits were purged within thirty minutes after the injection. In a few of the cases the later injections were followed by the evacuation of blood-stained stools.* The temperature was elevated from 1 to 3° F. within three hours. The maximum temperature was reached in about twenty hours. It continued above normal for from two to three days. Respiration was accelerated. The rabbits remained very quiet, sat in a crouched position, and usually the eyes were nearly closed. They ate very little the first day after the injection. After the second day they were usually bright and seemed to be quite well. These symptoms were repeated after each injection. The rabbits became emaciated. Those killed for examination revealed no macroscopic lesions, excepting that of anæmia. Those subsequently inoculated with hog-cholera virus, offered no resistance to the disease.

The maximum quantity of the sterilized suspension injected at one time was 3 cc. which was not sufficient, however, to produce death. It

* It is of interest to note that the severe symptoms produced by the intravenous injection of the agar suspension did not follow the introduction of the filtrate. This was determined by preparing a certain quantity of the suspension, placing it in an incubator for twenty-four hours, filtering it through a bougie of a Pasteur filter and injecting from 1 to 2 cc. of the filtrate into the ear vein of rabbits. The injection was followed by a rise in temperature of from 1.5 to 2.6° F., which subsided within eighteen hours. No other symptoms were detected. The injection of a similar quantity of sterile peptonized bouillon or normal salt solution likewise produced a slight rise of temperature.

was observed that when large quantities were injected at first, subsequent injections produced a milder reaction. Tubes of bouillon or agar were always inoculated with bits of tissue from the spleen or liver of the rabbits that died from the effect of the injections. These invariably remained sterile.

C.—EXPERIMENTS ON PIGS.

In order to extend the comparison between the immunizing effect of sterilized bouillon and agar cultures of hog-cholera bacteria, two experiments were made on pigs. The marked resistance obtained in the guinea-pigs with a small quantity of sterilized agar suspension indicated that this substance was more effective than the sterilized bouillon cultures. The effect on rabbits also indicated the presence of a more powerful substance in the agar culture than in the simple bouillon growths, although no immunizing properties were shown.

In the first experiment on pigs a suspension from an agar culture was used that was similar in concentration to that employed in the experiments on other animals. In the second trial the same quantity was injected but the suspension contained the growth from twice the area of agar surface used for the first. The total quantity given each time was divided into several doses, which were injected in different places beneath the skin, on the inside of the thigh, and over the abdomen.

The pigs selected were 3 months old and weighed from 45 to 50 pounds each. They were tested after the treatment by an intravenous inoculation of 6 cc. of a bouillon culture of hog-cholera bacteria. The other facts necessary for an understanding of these experiments are given in a tabulated form.

VI.—Table showing experiments on pigs with sterilized agar cultures of hog-cholera bacteria.

Experiment.	Pig number—	Quantity of emulsion injected.	Number of injections.	Time from first injection to inoculation with living bacteria.	Date of inoculation.	Controls died in—	Results.
		cc.		Days.		Days.	
I	59	50	3	34	Aug. 15, 1891	.....	Died in 4 days.
	62	50	3	34	do .....	.....	Died in 12 days; extensive ulceration in intestine.
	60	Control	.....	.....	do	3	
	61	Control	.....	.....	do	4	
II	67	50	3	26	Oct. 17, 1891	.....	Died in 5 days.
	68	50	3	26	do .....	.....	Recovered.
	71	50	3	26	do .....	.....	Do.
	69	Control	.....	.....	do	3	
	70	Control	.....	.....	do	3	
	74	Control	.....	.....	do	4	

In the first experiment pig No. 62 lived eight days longer than the checks, and exhibited very extensive ulcerations of the intestinal tract with slight lesions elsewhere in the body. This fact indicated that a certain amount of resistance had been produced which manifested itself by an unusually marked localization of the disease. There were no

lesions found at the points of injection of the sterilized agar suspension. In pig No. 67 there were several encysted abscesses in the subcutaneous tissue at the points where the agar suspension was injected. Pigs Nos. 68 and 71 were sick for a few days but fully recovered. The result of the second experiment was sufficiently positive to admit of the inference that two of the three pigs were made immune by the use of the agar cultures. The severity of the test inoculation is indicated by the fact that all of the control pigs and nearly all of the pigs (from the same herd) inoculated simultaneously in connection with certain other experiments carried on at this time perished. It is highly probable that pigs can be made insusceptible to the disease as acquired on the farm by repeated injections of sterilized suspensions of agar cultures. The attending expense of such a process, however, makes it impracticable.

EXPERIMENTS WITH THE BLOOD OF HOG-CHOLERA RABBITS STERILIZED BY HEAT.

In 1890 Selander* published some investigations in which he claimed to have produced, with the sterilized blood of swine-pest-infected pigeons, immunity in rabbits toward the bacillus of swine pest. This bacillus, according to personal observation of one of us, is identical with, or very closely related to, the hog-cholera bacillus, as found in this country.† The bacillus was passed by Selander through a long series of pigeons, and the blood of these pigeons, sterilized by heat, was used to produce immunity in rabbits. His experiments are briefly summarized as follows:

1. *Intravenous injections*.—A rabbit received in an ear vein, in three injections (April 19, May 5, and 9), 3.5 cc. in all of pigeon's blood, from the fifty-first, fifty-ninth, and sixty-sixth passages. The blood was heated for an hour at 57° C. Three days after the last injection the rabbit was inoculated with 0.15 cc. of pigeon's blood from seventy-first passage. It remained well. The control rabbit died in less than thirty-six hours. A second experiment was made, in which 4-5 cc. of sterilized blood was injected in 4 doses. Four days after the last injection the rabbit was inoculated with virulent pigeon's blood of the seventy-third passage. It remained well. The two control rabbits died in less than twelve hours.

2. *Subcutaneous injection*.—A rabbit received 15 cc. of sterilized blood in two doses (March 22, 5 cc.; April 18, 10 cc.). On May 13 it was inoculated subcutaneously with 0.15 cc. of blood of the seventy-first passage. It resisted, while the checks died in less than thirty-six hours.

The discrepancy between the pathogenic action of hog-cholera bacilli and that which Selander describes as characteristic of his culture was sufficient to arouse suspicion. This suspicion is strengthened by the statement of Metchnikoff that his work is a continuation of Selander's, and that he verified the latter's results. It has already been stated

* Contribution à l'étude de la maladie infectieuse des porcs connue sous les noms de hog-cholera, svinpest, pneumo-entérite infectieuse. Annales de l'Institut Pasteur, iv (1890), p. 545.

† See bulletin on Hog Cholera (1889), p. 181, for a history of the Danish disease.

that we have convicted Metchnikoff of working with the swine plague bacillus and calling it the hog-cholera bacillus in his publications. The evidence is thus very strong that through some inadvertence Selander worked with the swine-plague bacillus. However, as we have not been able to make a study of Selander's bacillus, his work is discussed here under hog cholera, and the reader will note in the following experiments a refutation of Selander's results as regards the hog-cholera bacillus, but a confirmation as regards the swine plague bacillus.

It was found in our experiments that rabbits inoculated with hog-cholera bacilli usually died during the night, and that it was impossible to obtain liquid blood from them post-mortem. For this reason rabbits were inoculated subcutaneously with hog-cholera bacteria, and in the last stage of the disease, presumably only a few hours before death would have occurred, they were killed by bleeding. The blood was collected in sterile tubes, defibrinated, and heated in a water bath for one hour at 58° C. In every case a gelatin roll culture was made prior to the heating with a small loop of the blood. In these innumerable colonies of hog-cholera bacteria developed, which showed that the blood contained enormous numbers of bacteria at the time the animals were killed. The heated blood was either used at once or kept at a low temperature (7-9° C.) until just before it was injected, when the required amount was heated to the body temperature. Previous experiments* had demonstrated the fact that hog-cholera bacteria are destroyed by exposing them to 58° C. for fifteen minutes. The certainty with which the bacteria are destroyed by such an exposure to heat led to the use of the blood in some cases immediately after it was heated, in order that no change might be produced by its standing. Its sterility, however, was tested in every case by subcultures in bouillon. These cultures invariably remained clear.

The rabbits from which the blood was obtained were inoculated subcutaneously with 0.1 cc. of a fresh bouillon culture of hog-cholera bacteria. A brief history of each of these animals is appended:

Rabbit No. 336, inoculated with virulent hog-cholera bacteria August 11, 1893; killed by bleeding August 15 (four and one-fourth days). The blood, after being sterilized, was kept at a temperature of from 7-8° C. for 20 hours, when it was used for the first injection.

Rabbit No. 310, inoculated August 15; bled August 19 (four and one-fourth days). The blood was used for the second injection immediately after it had been sterilized.

Rabbit No. 344, inoculated August 19; bled August 25 (six and one-fourth days). A portion of the blood was used immediately after it had been sterilized for the third injection. The remainder was kept at a temperature of from 7-8° C. for two days and then used for the fourth injection.

Rabbit No. 350, inoculated August 26; bled August 30 (four and one-fourth days). The blood was used immediately after its exposure to the heat for the fifth injection.

The post-mortem examination of the rabbits furnishing the blood showed, without exception, an enlarged spleen and necrosis in the liver. The three first were unable to stand when they were killed.

* Second Annual Report of the Bureau of Animal Industry (1885), p. 215.

The fourth rabbit (No. 350) was very sick, but evidently would have lived a few hours longer than the others. The number of colonies which developed in the gelatin roll cultures, made from the blood immediately after its defibrination, indicated that there were as many bacteria present in the blood of these animals as there are in the blood of rabbits which are allowed to die.

In this experiment with the sterilized blood young adult rabbits were used. The number of rabbits employed, quantity of blood injected, and the result of the test inoculation with hog-cholera bacteria are given in the following table:

VII.—Tables showing the immunizing effect of sterilized blood of rabbits suffering from hog cholera.

1. STERILIZED BLOOD INJECTED INTRAVENOUSLY.

Source of blood.	Rabbit No. 336.	Rabbit No. 310.	Rabbit No. 344.	Rabbit No. 344.	Rabbit No. 350.	Total amount injected.	Inoculated subcutaneously with 0.1 cc. of a bouillon culture hog-cholera bacteria.	Results.
Date of injection.....	Aug. 16.	Aug. 19.	Aug. 25.	Aug. 27.	Aug. 30.			
Rabbit—	cc.	cc.	cc.	cc.	cc.	cc.		
No. 337.....	0.75	1.30	1.30	1	2.05	6.40	Sept. 3, 1892...	Died Sept. 8, 1893.
No. 338.....	1	1.30	1.30	1	1.80	6.40	do	Do.
No. 339.....	1.40	1.30	1.30	1	1.40	6.40	do	Died Sept. 9, 1893.
No. 348.....			1	1.25	1.40	3.65	do	Do.
No. 349.....			1	1.25	1.40	3.65	do	Died Sept. 7, 1893.
No. 355.....	Check.						do	Died Sept. 8, 1893.

2. STERILIZED BLOOD INJECTED SUBCUTANEOUSLY.

Source of blood.	Rabbit No. 336.	Rabbit No. 310.	Rabbit No. 344.	Rabbit No. 344.	Rabbit No. 350.	Total amount injected.	Inoculated subcutaneously with 0.1 cc. of a bouillon culture hog-cholera bacteria.	Results.
Date of injection.....	Aug. 17.	Aug. 19.	Aug. 25.	Aug. 27.	Aug. 30.			
Rabbit—	cc.	cc.	cc.	cc.	cc.	cc.		
No. 340.....	2.8	2.6	2.6	2	5	15	Sept. 3, 1893...	Died Sept. 7, 1891.
No. 343.....	2.8	2.6	2.6	2	5	15	do	Do.
No. 355.....	Check.						do	Died Sept. 9, 1893.

At the same time a number of guinea-pigs were treated subcutaneously with sterilized blood from the same rabbits. This experiment is summarized in the subjoined table:

VIII.—Table showing the immunizing effect on guinea-pigs of sterilized blood of rabbits suffering from hog cholera.

Source of blood.	Rabbit No. 336.	Rabbit No. 310.	Rabbit No. 344.	Rabbit No. 344.	Rabbit No. 350.	Total amount injected.	Inoculated subcutaneously with 0.2 cc. bouillon culture of hog-cholera bacteria.	Results.
Date of injection.....	Aug. 16.	Aug. 19.	Aug. 25.	Aug. 27.	Aug. 30.			
Guinea-pig—	cc.	cc.	cc.	cc.	cc.	cc.		
No. 270.....	0.5	1.3	1.3			3.1	Sept. 3, 1893...	Died Sept. 9.
No. 280.....	1	1.3	1.3	1		4.6	do	Do.
No. 272.....				1.25	1.4	2.65	do	Died Sept. 10.
No. 283.....				1.25	1.4	2.65	do	Do.
No. 288.....	Check.						do	Do.
No. 289.....	do						do	Do.

It will be observed that even a slight degree of immunity was not produced. While the results differ from those obtained by Selander they are in conformity with those heretofore obtained in this laboratory with hog-cholera bacteria.

The toxic effect produced in the rabbits by the intravenous injection of the sterilized blood was very slight. The temperature rose from 1° to 1.8° F. after the first injection, but subsequently no elevation was detected. This was true of the subcutaneous injections in both rabbits and guinea-pigs. At no time did the animals refuse food, although they appeared to be unusually quiet for a short time after the first injection.

EXPERIMENTS WITH THE BLOOD SERUM OF RABBITS MADE INSUSCEPTIBLE TO FATAL DOSES OF HOG-CHOLERA BACILLI INTRODUCED UNDER THE SKIN.

These experiments were undertaken primarily to examine into the claims of Metchnikoff concerning the efficacy of blood serum from immune rabbits as a preventive and curative of hog cholera artificially induced in rabbits by inoculation.

In the course of these investigations a culture of the "hog-cholera" bacillus used by Metchnikoff in his work was asked for and kindly sent for examination. The study of this culture showed that Metchnikoff had not had the hog-cholera bacillus at all, but the swine-plague bacillus.* How this unfortunate mistake had come about it is not worth while to speculate upon here. It is sufficient to state that the persistence with which European observers have at first denied the existence of one or the other of these pathogenic forms and then confounded them, one with the other, is almost entirely responsible for the confusion which, from their point of view, exists in this subject.

The results obtained by Metchnikoff at first inexplicable are thus easily interpreted, and they agree entirely with the results detailed in

* Metchnikoff kindly sent the blood of a guinea-pig inoculated with the bacteria in a sealed glass tube. Two of these tubes were examined and in both the same bacteria were found in a state of purity. Cultivated on various substrata they presented all the characters of swine-plague bacteria as found in this country. The bouillon growth is always feeble, the agar growth quite vigorous, forming a grayish membrane on the agar surface. In bouillon and on agar the bacteria appear as very minute cocci, having at times a marked dancing (Brownian?) motion utterly unlike the rapid spontaneous movement of hog-cholera bacilli. The characteristic polar stain so commonly seen in preparations from the tissues of rabbits is only rarely recognizable in cultures. On agar plates prepared in closed Petri dishes the colonies emit a peculiar, disagreeable odor very characteristic of the whole group of swine-plague bacteria. In tubes of gelatin or on plates development remains nearly always invisible to the eye. Milk remains unchanged. On potato there is no visible growth. In glucose bouillon gas is not set free.

The pathogenic action as shown on rabbits was equally peculiar to the swine-plague group.

November 22, 1892. Male rabbit, $2\frac{1}{16}$ pounds, was inoculated subcutaneously with two drops of blood from one of the original sealed pipettes.

November 26. Found dead. At site of inoculation there was a small area of puru-

this article, provided we substitute the words "swine-plague bacillus" wherever he has used the words "hog-cholera bacillus." A description of his experiments is therefore omitted here and given on page 74, together with the work on the protective action of the blood serum of rabbits made insusceptible to swine plague.

In our experiments blood serum from rabbits B, No. 205 and No. 232, was used. (*See* p. 43.)

The rabbits were secured and anæsthetized with chloroform or ether. A carotid or a femoral artery was laid bare with proper aseptic precautions and a sterile glass cannula inserted. The blood was allowed to flow into sterile pear-shaped glass bulbs and kept over night in a temperature of about 70° F. The clear serum was withdrawn with sterile pipettes on the following day and kept in a refrigerator.

The following table summarizes the first experiment:

IX.—Table showing immunizing efficiency of serum from rabbit B.

Blood drawn ...	Dec. 2, 1892.*		Dec. 7.		Dec. 14.		Total quantity of serum injected.	Inoculation with 0.15 cc. virulent bouillon culture.	Result.
	Dec. 3.	Dec. 5.	Dec. 8.	Dec. 9.	Dec. 15.	Dec. 16.			
Rabbit—	cc.	cc.	cc.	cc.	cc.	cc.	cc.		
No. 403.....	1.4	1.4	1.4	.....	1.4	1.4	7	Dec. 29.....	Dead Jan. 3.
No. 404.....	1.4	1.4	1.4	.....	1.4	1.4	7	Dec. 29.....	Do.
No. 378.....	.....	.....	1.4	1.4	1.4	1.4	5.6	Dec. 29.....	Do.
No. 405 (control).....	.....	.....	.....	.....	.....	.....	.....	Dec. 29.....	Do.
Guinea pig, 354.	1.4	1.4	1.4	.....	1.4	1.4	7	Dec. 29.....	Dead Jan. 13.

* Last inoculation with virulent culture September 15, 1892.

From this table it will be noted that there was no appreciable amount of resistance acquired by the rabbits during the treatment with blood serum. The guinea-pig lived about eight days longer than the usual period. Unfortunately no control was used with this animal as the use of the guinea-pig was rather an after-thought in this experiment. It is not necessary to give the autopsy notes of these animals, as they present nothing unusual.

lent infiltration with surrounding hemorrhages and ecchymoses. Extravasations on omentum and on lower portion of large intestine. Spleen large, dark, and firm. In left lung 5 small hemorrhagic foci. In stained cover-glass preparations of spleen pulp a large number of bacteria showing the polar stain very well. In heart's blood very few. Cultures from blood and spleen positive.

January 10, 1893. A rabbit received into an ear vein 0.12 cc. of a bouillon culture twenty-four hours old. This culture was derived from the blood in the sealed pipette through agar plates and agar subcultures from a colony. The rabbit was found dead next morning with hyperemic lungs and punctiform ecchymoses under serosa of large intestine. Immense numbers of polar-stained bacteria in the spleen. This organism has been kept growing up to the present with no change in its characters beyond a gradual decline of virulence.

The following table summarizes a later experiment with the serum of rabbits Nos. 205 and 232:

X.—Table showing immunizing efficiency of serum from rabbits 205 and 232.

Blood from.....	No. 205.*		No. 232.†		No. 205.		Total quantity of serum injected.	Inoculation with virulent bouillon culture Feb. 13.	Results.
When drawn.....	Jan. 4, 1893,		Jan. 11.		Jan. 23.				
Date of injection of serum.....	Jan. 5.	Jan. 6.	Jan. 12.	Jan. 13.	Jan. 25.	Jan. 28.			
	cc.	cc.	cc.	cc.	cc.	cc.	cc.		
Rabbit—									
No. 416.....	1.3	1	1	1.4	1.4	0.5	6.6	0.06	Dead Feb. 18.
No. 413.....	1.3	1	1	1.4	1.4	0.5	6.6	0.06	Do.
No. 415 (control).....								0.06	Dead Feb. 29.
Guinea pig—									
No. 365.....	1.3	0.75	1	1.4	1.4	.....	5.85	0.09	Dead Feb. 22.
No. 366.....	1.3		1	1.4	1.4	.....	5.1	0.09	Dead Feb. 29.
No. 367 (control).....								0.09	Do.
No. 369 (control).....								0.09	Dies Feb. 20 (noon).

* Last inoculation with virulent culture of hog-cholera bacilli was made September 15, 1892.

† Last inoculation July 29, 1892.

The guinea-pigs weighed about 1.5 pounds, the rabbits 3 to 3.5 pounds.

In connection with the blood-serum injections a curious effect on the guinea-pigs was noticed. In No. 365 a bluish discoloration 1 to 1½ inches in diameter appeared at the place of injection (abdomen), with more or less firm infiltration in the subcutaneous tissue. At the time of the test inoculation the lesion had disappeared.

In No. 366 a similar infiltration, without discoloration, appeared after two injections, one of which became ulcerated. This also had healed February 13.

When first observed it was suspected that perhaps a few hog-cholera bacilli had been in the animals from which the serum was drawn. This supposition was disposed of by the fact that no infiltration or reaction of any kind followed the injection in the more susceptible rabbits. To what other causes this phenomenon may be referred to, inquiries have not yet been made. It may have been due either to the irritating action of the rabbit's serum *per se* or to some change in the serum brought about by the acquired immunity.

This experiment may be objected to, as illustrating the absence of any protective substance in the blood in appreciable quantity, on two grounds—the long interval between the drawing of the blood and the last virulent inoculation, and the long interval between the last blood-serum injection and the test inoculation (sixteen days). These objections are to a certain extent well founded. There were, however, sufficient reasons for the delay. The hog-cholera bacillus is not eliminated from the organs of immune rabbits for *at least* a month after inoculation and it probably persists much longer. Hence any haste in the collection of the blood may either miss the period of maximum protective power or it may lead to the collection of blood containing living

hog-cholera bacilli. The test inoculation following the blood-serum treatment was delayed to give the indurations and ulcers produced by the blood serum in guinea-pigs sufficient time to heal.

The absence of any retarding effect of the blood serum on the disease in rabbits under the conditions of the experiment shows that any appreciable increase of resisting power is not likely to be obtained by increasing the quantity of the serum. This result is in entire accord with the negative outcome of the other immunizing methods applied to rabbits. With guinea-pigs the result is somewhat different. There seems to have been a slight degree of immunity induced in the guinea-pig used in the first blood-serum experiment. This also is in accord with the sterile bouillon experiment and the blood-serum experiment on guinea-pigs, described below.

DOES THE BLOOD OF IMMUNE RABBITS POSSESS ANY BACTERICIDE OR ANTITOXIC POWER?

Only one trial was made. Some preliminary experiments carried out by Dr. C. F. Dawson in this laboratory had shown the absence of any bactericide action of the blood serum of immune rabbits on hog-cholera bacilli. The blood serum used by him was obtained from one or the other of the rabbits Nos. 205, 232, and B.

In January of 1894, rabbit B was killed and a small quantity of blood-serum obtained, which was used as follows :

A definite quantity of a bouillon culture of hog-cholera bacilli, twenty-four hours old, was added by means of a carefully graduated drop pipette to a definite quantity of serum and the mixture injected into rabbits subcutaneously after a certain length of time, as indicated in the subjoined table:

XI.—Table showing results of injection of rabbits with mixture of hog-cholera bacilli and serum.

Rabbit.	Serum mixture contains—		Time elapsing between mixing serum and bacilli and inoculation into rabbit.	Date of inoculation.	Result.
	Of bouillon culture of hog-cholera bacilli.	Serum.			
	cc.	cc.	Hrs. min.		
No. 127	.033	0.5	0 15	Jan. 10, 1894	Dead January 17.
No. 128	.033	0.5	1 48	do	Dies January 15, noon.
No. 126	.033	0.5	24 00	Jan. 11, 1894	Dies January 16.
No. 84	.033	*0.5	.....	Jan. 10, 1894	Dies January 13.

* Sterile bouillon.

The cause of death in these animals was determined by a careful autopsy, by cultures and by the examination of cover-glass preparations of the spleen pulp. There seems to have been a slight retardation of death in favor of the fifteen-minute serum mixture. However, the period of the disease produced by it was within the normal limit, while

that of the control rabbit was shorter than is usually the case. Any protective action of the serum mixture can not be deduced. It should be stated that the rabbit furnishing the serum had not been inoculated with hog-cholera bacilli since September 15, 1892.

EXPERIMENT ON GUINEA-PIGS WITH BLOOD SERUM FROM GUINEA-PIGS IMMUNIZED AGAINST HOG-CHOLERA BACTERIA.

A single experiment was made on guinea-pigs to test the immunizing efficacy of the blood serum from guinea-pigs previously made immune to hog cholera by artificial means. The method of immunizing the animals from which to obtain the serum was the subcutaneous injection of sterilized bouillon culture of hog-cholera bacteria. A detailed account of the immunization of these guinea-pigs is given on p. 50, under the numbers 474, 473, and 453. No. 453 had been inoculated twice with hog-cholera bacteria, the other two once only.

Guinea-pig No. 474 was bled twenty-four days after the test inoculation and seventeen days after the control guinea-pig had died.

Guinea-pig No. 473 was bled thirty-seven days after the test inoculation and thirty-one days after the control had died.

Guinea-pig No. 453 was bled thirty-eight days after the second test inoculation and thirty-two days after the death of the control animal.

At the time the guinea-pigs were bled they were in excellent condition. After they had been bled and killed a careful examination showed that they were free from any lesions of disease. As a precautionary measure, however, tubes of bouillon were inoculated with several large loops of the blood and with a large piece of the spleen of each animal. Stained cover-glass preparations from the various organs showed no bacteria. The tubes of bouillon inoculated with the blood remained clear, but those inoculated with the spleen developed into pure cultures of hog-cholera bacteria on the second day. One rabbit was inoculated with each of these cultures. All died of hog cholera in the usual time.

The length of time during which the hog-cholera bacteria remained alive in the spleen of these animals and the unchanged virulence are facts worthy of notice. The permanent sterility of the bouillon tubes inoculated with the blood would indicate that the bacteria were not present in this fluid at the time the guinea-pigs were killed, and that the serum used was free from living bacteria.

To obtain the blood from the immune guinea-pigs the animals were etherized, the hair removed from the neck, and the skin thoroughly disinfected. The carotid artery was then exposed with sterile instruments and the animal held in such a position that the blood from the incised artery could run into a sterile funnel and thence into a sterilized pear-shaped glass bulb. About 25 cc. of blood was obtained from each animal. This was placed in a temperature of about 8° C. From 4 to 7 cc. of clear serum was obtained from each animal. The injection

of guinea-pigs with the serum, the subsequent test inoculation, and its result are summarized in the subjoined table:

XII.—Table showing immunizing effect of blood serum from immune guinea-pigs injected subcutaneously.

Source of serum.	Guinea-pig— No. 474.	Guinea-pig— No. 474.	Guinea-pig— No. 473.	Guinea-pig— No. 473.	Guinea-pig— No. 453.	Total quantity of serum injected.	Inoculated with 0.1 cc. bouillon culture of hog- cholera bacteria.	Results.
Date of injection.	Oct. 20, 1893.	Oct. 25, 1893.	Nov. 2, 1893.	Nov. 6, 1893.	Nov. 9, 1893.			
Guinea-pig—	cc.	cc.	cc.	cc.	cc.	cc.		
No. 1.....	1	1	1	1	2	6	Nov. 13, 1893 ..	Died Nov. 27, 1893.
No. 4.....	1	1	1	1	2	6	do	Died Dec. 7, 1893.
No. 2.....				1.5	3	4.5	do	Died Nov. 24, 1893.
No. 5.....					2	2	do	Do.
No. 8.....						check	do	Do.

The results obtained in this experiment are more positive than those obtained by the use of sterilized rabbit's blood. While the injection of 2 cc. of the serum produced no effect the, use of 6 cc. produced an appreciable resistance. The large number of tubercle-like bodies found in guinea-pig No. 2 may be taken as an indication of partial immunity, although it died with the check. No. 4 survived the inoculation for twenty-four days. The amount of resistance induced by the blood serum was no greater in proportion to the quantity used than that obtained with the agar cultures sterilized by heat.

SWINE PLAGUE

The swine-plague bacteria used in this series of experiments are described in the Special Report on the Cause and Prevention of Swine Plague, Department of Agriculture, 1891 (p. 57). They were sufficiently virulent to destroy rabbits inoculated subcutaneously with 0.001 cc. of a fresh bouillon culture in less than twenty hours. The following experiments are similar in detail to those made with hog-cholera bacteria.

EXPERIMENTS WITH STERILIZED BOUILLON CULTURES OF SWINE-PLAGUE BACTERIA.

In these experiments young adult rabbits were used. The sterilized bouillon cultures were prepared and test inoculations were made in accordance with the methods given in the hog-cholera experiments. Control rabbits were always used. These died without exception within twenty-four hours. On this account they are omitted from the table giving the details of the treated rabbits.

The immediate, toxic effect of the injection of the sterilized bouillon cultures varied according to the method of injection. The rabbits that received the cultures in the peritoneal cavity sat very quietly for a few hours, but otherwise they appeared to be well. The intravenous injection produced a more marked depression. The animals sat in a crouched position, refused food, and offered no resistance to handling. The

temperature rose 1 to 1.5° F. Usually the effect was noticeable for about twenty-four hours, after which time the animals appeared to be in their normal condition. These well-marked disturbances occurred after the first injection only. Subsequent injections produced very little and often no appreciable effect. A summary of the facts in this experiment is given in the following table:

XIII.—Table showing results of experiments with sterilized bouillon cultures of swine-plague bacteria.

Rabbit—	Date of first injection.	Method of injection.	Total quantity of sterilized culture injected.	Number of injections.	Test inoculation with living swine-plague bacteria.	Results.
No. 12....	Dec. 26, 1890	Ear vein...	cc. 7	5	Jan. 16, 1891	Died Jan. 19. Severe local reaction and peritonitis.
No. 13....	Jan. 26, 1891	do.....	7	5	Feb. 24, 1891	Died Feb. 26.
No. 14....	Apr. 24, 1891	do.....	8	3	May 19, 1891	Died May 20.
No. 15....	do.....	do.....	12	4	May 26, 1891	Died June 3. Severe local reaction, pleuritis, and peritonitis.
No. 16....	do.....	do.....	16	5	June 5, 1891	Died June 11, 1892. Very slight local reaction, which healed; large closed abscess in abdominal cavity.
No. 17....	do.....	do.....	16	5	do.....	Recovered. Killed for examination Mar. 24, 1892.
No. 18....	Mar. 10, 1891	Abdominal cavity.	20	4	Mar. 31, 1891	Died Apr. 1.
No. 19....	do.....	do.....	20	4	do.....	Do.
No. 20....	do.....	do.....	40	8	Apr. 17, 1891	Died Apr. 18.
No. 21....	do.....	do.....	40	8	do.....	Recovered. Severe local reaction. Killed for examination Feb. 9, 1892.

The foregoing table shows that the injection of the sterilized cultures into the veins produced a greater degree of resistance than the injection into the abdominal cavity. It will be found from the appended post-mortem notes that the degree of resistance on the part of the treated animal was accompanied by variations in the course of the disease, so that when a rabbit resisted the inoculation of virulent swine-plague bacteria for a number of days it exhibited lesions similar to those found in rabbits that died from an inoculation of an attenuated swine-plague germ which required several days to destroy life. These variations are especially well marked in rabbits Nos. 12 and 15. The effect of the inoculation in rabbit No. 16 is of special interest, as the animal showed no disturbance for several months after the inoculation, but died more than a year later. This variation in the course of the disease will be more fully illustrated in the experiments with agar cultures. The interesting points in the post-mortem notes of these rabbits are appended. Attention is particularly called to those of rabbits Nos. 12, 15, and 16.

Rabbit No. 12 lived three days after inoculation. There was quite a severe purulent infiltration at the place of inoculation. Surrounding this the blood vessels were much injected; about 4 cm. from the point of inoculation toward the knee-

fold a small mass of purulent substance. On the cæcum a small quantity of a grayish, pasty exudate was collected into bands and shreds which contain leucocytes and an innumerable number of swine-plague bacteria. Under the serosa of the small intestine, excepting duodenum, are numerous blood extravasations of irregular outline. Lungs œdematous and partially collapsed. A large number of polar-stained bacteria in preparations from the spleen and blood. A cover-glass touched to the pleura on the diaphragm and stained showed a few swine-plague bacteria.

Rabbits Nos. 13 and 14 died within forty-eight and twenty-four hours of acute swine plague.

Rabbit No. 15 lived eight days. At the point of inoculation the subcutis was infiltrated with a purulent exudate extending over an area 6 cm. in diameter; subjacent muscles necrosed; surrounding blood vessels injected. Over intestines were a few fine shreds of exudate. Liver hyperæmic. Spleen very dark. Kidneys pale. Right lung hyperæmic; pleura, both parietal and visceral, covered with a thin cellular exudate. In cephalic lobe two foci about 1 cc. in diameter in a state of grayish consolidation. The left pleural cavity lined with a quite thick membranous exudate which covers the entire surface of the lung. On the dorsal surface of the principal lobe an area 2 cm. in diameter and extending through the lung was consolidated, of a yellowish-gray color, apparently necrosed; the remaining portion of the principal lobe hyperæmic; cephalic lobe collapsed. Pericardium covered with a thin cellular exudate. Heart muscle pale. The exudate contained an innumerable number of swine-plague bacteria. Very few bacteria in cover-glass preparations from the spleen.

Rabbit No. 16 lived one year and six days after inoculation. This rabbit appeared to be perfectly well for several months after the inoculation. In the spring of 1892 it was observed to be emaciated to a considerable degree. It died June 11, 1892. The post-mortem examination showed the rabbit to be very poor. The abdominal cavity contained a very large tumor extending from the pubes cephalad and covering the kidneys and crowding the intestines up under the ribs. The cæcum was lying over the stomach. The tumor was found to be beneath the peritoneum, the blood vessels of which were injected. The ovaries, Fallopian tubes, ureters, and rectum were plainly visible on the convex surface of the tumor. An incision showed the tumor to consist of an outer rather firm wall about 2 mm. thick, containing a whitish substance resembling fine wheat-flour paste in consistency. A microscopical examination showed it to consist of broken-down pus cells and fine granules. The tumor when removed weighed 900 grams or nearly one-half the entire weight of the animal (total weight 1,980 grams). The liver, spleen, and kidneys were small and firm. Heart and lungs apparently normal. A tube of bouillon was inoculated and a series of agar plate cultures made from the contents of the tumor. These developed into pure cultures of swine-plague bacteria. The virulence of the germ was tested on rabbits with the following results:

June 15. *Rabbit No. 286* was inoculated subcutaneously with 0.30 cc. of a bouillon culture. June 18, rabbit found dead with lesions characteristic of attenuated swine plague, i. e., severe local infiltration and peritonitis.

June 30. *Rabbit No. 316* was inoculated subcutaneously with 0.25 cc. of a bouillon culture made from the blood of rabbit No. 286. July 1, rabbit found dead. Innumerable swine-plague bacteria in the organs.

July 2. *Rabbit No. 315* was inoculated subcutaneously with 0.01 cc. of a bouillon culture from rabbit No. 316. It died within twenty-four hours.

These inoculations were sufficient to restore the virulence of the bacteria inoculated into rabbit No. 16, and to demonstrate the identity of the bacteria obtained from the closed abscess with the bacteria inoculated a year previously.

Rabbit No. 17. This animal was killed for examination March 24, 1892. It was found in good condition. No bacteria were found either in cover-glass preparations or in cultures from the organs.

Rabbits Nos. 18, 19, and 20 died from the acute, septicæmic form of swine plague. *Rabbit No. 21*, killed February 9, 1892, nearly ten months after its inoculation. Very much emaciated. Beneath the skin over abdomen several small cysts containing pus. Projecting into abdominal cavity from the dorsal wall is a tumor about 8 cm. in diameter. Upon inspection it was found to consist of a grayish, pasty, purulent substance inclosed in a sac having a wall about 2 mm. in thickness. A tube of agar inoculated with a loop of the heart's blood remained clear. A tube of bouillon inoculated from the contents of the tumor developed into a pure culture of swine-plague bacteria. A rabbit inoculated subcutaneously with 0.25 cc. of this culture died within twenty-four hours.

EXPERIMENTS WITH STERILIZED SUSPENSIONS OF AGAR CULTURES OF SWINE-PLAGUE BACTERIA.

In the preparation of the suspensions of the agar culture the same method was pursued as in the hog-cholera experiments. The cultures varied in age from two to five days. The surface growth was diluted with bouillon and filtered through sterilized Japanese filter paper, to remove all masses of agar and clumps of bacteria. The filtrate had a grayish, turbid appearance. The suspension was distributed in large sterile test tubes, closed with cotton plugs and sterilized by heating in a water bath for one hour at 60° C. The sterility of the heated cultures was determined by means of subinoculations in bouillon. Control rabbits were used in all experiments, but are omitted from the table. As in the preceding experiment, they invariably succumbed to the subcutaneous inoculation within twenty-four hours. The rabbits used in the experiment were young adults. The details of this experiment are given in the following table:

XIV.—Table showing results of experiments with sterilized suspensions of agar cultures of swine-plague bacteria.

Rabbit—	Date of first injection.	Method of injection.	Total quantity of sterilized suspension used.	Number of injections into which it was divided.	Inoculated with living swine-plague bacteria.	Results.
			cc.			
No. 38....	May 4, 1891	Abdominal cavity.	4.5	3	May 19, 1891	Died May 25, 6 days after inoculation.
No. 35....	...do	...do	7.5	4	May 26, 1891	Died Feb. 2, 1892, 9 months after inoculation.
No. 37....	...do	...do	7.5	4	...do	Recovered.
No. 36....	...do	...do	7.5	4	...do	Do.
No. 51....	June 9, 1891	...do	3	2	June 19, 1891	Died June 22, 3 days after inoculation.
No. 50....	...do	...do	3.5	3	June 29, 1891	Recovered.
No. 52....	...do	...do	12	4	...do	Do.
No. 53....	...do	...do	12	4	...do	Do.
No. 23....	...do	Ear vein...	1.5	2	June 19, 1891	Do.
No. 54....	...do	...do	2	3	June 29, 1891	Do.
No. 76....	June 29, 1891	...do	2.5	3	July 7, 1891	Died July 8, with control rabbit.
No. 77....	...do	...do	2.5	3	...do	Do.
No. 130....	Oct. 1, 1891	...do	2	1	...	Died Oct. 2, from the effect of treatment.
No. 129....	...do	...do	3.5	3	Oct. 15, 1891	Died Nov. 4, 20 days after its inoculation.
No. 152....	Oct. 16, 1891	...do	5.5	3	Nov. 19, 1891	Recovered.
No. 79....	June 29, 1891	Subcutis...	4	3	July 7, 1891	Died July 8, with control rabbit.
No. 78....	...do	...do	8.5	5	July 18, 1891	Recovered.

The injections of sterilized suspension of swine-plague bacteria were repeated at intervals of from two to six days according to the effect produced. Time was allowed for the normal condition of the animal to become restored after each injection before the latter was repeated. In case of the intravenous injection this period was much longer than in the other cases. The test inoculation was made in from two to six days after the last injection.

The immediate or toxic effect of the agar suspension was more severe than that produced by the bouillon culture. The abdominal injection was followed by a slight indifference on the part of the rabbits when handled and their refusal of food. The intravenous injection, however, produced a marked effect. There was an elevation of the temperature of from 0.5° to 2° F. within two hours. Respiration accelerated. Eyes usually more or less closed. In from twelve to eighteen hours the temperature reached 104.5° to 105.6° F. which elevation continued for about twenty-four hours, when it rapidly subsided to the normal. During this time the rabbits refused food, offered no resistance to handling, and the fur had a ruffled appearance. In some cases the injection was followed within twenty minutes by a copious evacuation of the bowels. Subsequently the rabbits appeared to suffer from tenesmus for a shorter or longer time. The second injection produced the same symptoms. After the third injection the reaction was very slight and often inappreciable.

The subcutaneous injections produced no appreciable constitutional symptoms. There was a slight infiltration of the subcutis at the points of injection which disappeared in a few days.

It is of interest to note that in rabbits Nos. 38 and 51 which received small quantities of the suspension there was very severe local reaction after the inoculation with the strong virus followed by peritonitis and death. In No. 50 there was severe local reaction with recovery. In those that received 7.5 cc. the local reaction was less severe and recovery followed in two of the three cases. No. 35 is extremely interesting from the fact that the rabbit lived nearly ten months. In the two rabbits which received 12 cc. each, there was scarcely any local reaction and the animals remained apparently perfectly well.

It is difficult to understand the effect of the intravenous injections. Rabbits Nos. 23 and 54 resisted the inoculation of the strong virus, though they had received only a small quantity of the suspension, while Nos. 78 and 79 offered no resistance, although they had received a greater quantity. The subcutaneous injection of the agar suspension was equal to the abdominal injection in efficiency. The rabbits that perished after showing a marked resistance were affected with lesions that are of sufficient interest to be briefly recorded:

Rabbit No. 38 resisted sixty days. A purulent infiltration at point of inoculation over an area 3 cm. in diameter; subjacent muscle pale. Spleen slightly enlarged. Liver congested. The pleura of both lungs and parietes covered with a grayish

friable exudate consisting of cells and bacteria. Exudative pericarditis. Lungs deeply hyperemic, only partially collapsed.

Rabbit No. 51 resisted three days. A purulent infiltration in the subcutis at point of inoculation over an area of about 2 cm. in diameter. Over abdominal viscera a grayish exudate composed of round cells and swine-plague bacteria.

Rabbit No. 35 resisted for nearly nine months. Rabbit very much emaciated. At point of inoculation a closed abscess about the size of a horse-chestnut, containing pus of a pasty consistency. Thoracic and abdominal organs pale; brain and spinal cord apparently normal. Culture media inoculated from the local abscess and blood remained clear. The time which had elapsed (nearly ten months) after the inoculation was sufficiently long to admit of other causes, but it seems more likely on account of the local abscess that the swine-plague inoculation was primarily responsible.

Rabbit No. 129 resisted twenty days. It exhibited a small abscess at the point of inoculation. The abdominal cavity contained considerable clear serum. The heart and lungs were encased in a thick layer of purulent substance containing innumerable swine-plague bacteria. Lungs nearly collapsed; no hepatization.

Rabbit No. 130 died from the effect of an injection of 2 cc. of the sterilized emulsion. In caecum several punctiform hemorrhages. Liver and kidneys were hyperemic. The spleen was congested and somewhat enlarged. On the pleural side of the diaphragm were several punctiform hemorrhages; they were also present in the meninges of the spinal cord and in the subcutis over the cranium. No peritonitis or pleuritis. No swine-plague bacteria in cultures from the organs.

Rabbit No. 50 was killed February 25, 1892, nearly eight months after inoculation. On abdomen, at point of inoculation, there was an open abscess about 3 cm. in diameter. Its contents were of a grayish, pasty consistency. Otherwise the animal was in excellent condition. As the abscess was open no cultures were made from it.

Rabbit No. 53 was killed February 18, 1892, nearly eight months after inoculation. Rabbit in excellent condition. Beneath the skin over the abdomen there were two small abscesses; one about the size of a small walnut had ruptured, the other was about 3 cm. long and 1 cm. in diameter. It contained a pasty, yellowish, purulent substance. An examination showed only pus cells and degenerated cell substance. A tube of bouillon inoculated with a loop of the contents remained clear.

Rabbit No. 52 was killed February 12, 1892, seven and one-half months after inoculation. Rabbit in a well-nourished condition. At the point of inoculation on the side of the abdomen there was an abscess 8 by 3 cm., composed of a considerable number of small cysts which were found to communicate with each other. The contents consisted of a thick, pasty material composed of pus cells in a state of fatty degeneration. Lungs congested, hypostatic. Heart muscle pale, otherwise normal. A tube of bouillon inoculated with the blood remained clear. One inoculated from the contents of the abscess developed into a pure culture of the swine-plague germ, whose virulence was tested as follows:

February 18, a rabbit was inoculated subcutaneously with 0.2 cc. of the bouillon culture from rabbit No. 52. February 25, rabbit was found dead. Extensive purulent infiltration into the subcutis and inter-muscular tissue extending over an area 9 cm. in diameter, agglutinating the thigh to the abdominal wall. Cephalic lobes of both lungs in a state of gray hepatization containing small abscesses. A pure culture of the swine-plague germ was obtained from the spleen.

Rabbit No. 36 chloroformed February 15, 1892, eight and one-half months after its inoculation. Rabbit in a well-nourished condition. On the thorax there was an abscess about the size of a hen's egg which had ruptured. Surrounding this were several encysted abscesses varying from 0.5 to 2 cm. in diameter containing a thick pasty, purulent substance. These did not appear to have any communication with each other or with the ruptured abscess. Otherwise the rabbit was apparently normal. A tube of bouillon inoculated with a bit of the contents of one of the

cysts developed into a pure culture of the swine-plague bacillus. On February 18, a rabbit was inoculated subcutaneously in the thigh with 0.2 cc. of this bouillon culture. It was found dead on the following morning. Innumerable swine-plague bacteria were found in stained cover-glass preparations from the various organs.

The remaining animals, which showed no external lesions or symptoms of disease after a few months, were used for other purposes.

The presence of swine-plague bacteria in the subcutaneous abscesses of rabbits Nos. 52 and 36 is a further illustration of the long period of time during which these organisms will remain alive in the lesions which they produce. Attention is called to the attenuated condition of the bacteria obtained from rabbit No. 52 and to the virulence of those isolated from a similar abscess in rabbit No. 36.

Although the rabbits killed for examination exhibited no lesions which presumably would not have been overcome had the animal been permitted to live, the fact remains that they were not made totally insusceptible to the action of the virulent bacteria. Here again is an illustration of the dangers of vaccination, for although the rabbits survived, they could not be considered as safe companions for other susceptible animals so long as they harbored the virus of the disease in abscesses which were liable to rupture at any time.

EXPERIMENTS WITH THE FILTRATE OF AGAR SUSPENSIONS.

The successful production of immunity in rabbits with sterilized turbid suspensions of swine-plague bacilli grown on the surface of nutrient agar made it desirable to test the immunizing properties of the bouillon in which these bacilli had been suspended for several hours and then removed by filtration. Such an experiment would inform us how far the bodies of the bacteria themselves, or any substance derived from them and passing promptly into solution in the suspending fluid, would be responsible for the immunizing action.

The suspensions from agar cultures were prepared as already described and placed in an incubator for twenty-four hours. They were then sterilized by heat as before and filtered through a Pasteur bougie, which removed all of the bacteria. The filtrate was perfectly clear and of a dark amber color.

Four rabbits were injected intravenously with the filtrate. Two of them received 3 cc. in three injections of 1 cc. each, and one received 3 cc. in two injections, and one received 4 cc. in three injections. They were subsequently inoculated with virulent swine-plague bacteria. They died in less than twenty-four hours with the control animals.

The injection of the filtrate was followed by a slight elevation of temperature and general depression, which was of much shorter duration than that produced by the suspension. A control experiment showed that similar symptoms were developed by the injection of an equal quantity of sterilized bouillon or normal salt solution.

EXPERIMENTS WITH DEFIBRINATED, STERILIZED BLOOD OF RABBITS
AFFECTED WITH SWINE PLAGUE.

The culture of swine-plague bacteria used in the preceding experiments was also used here. It was fatal to rabbits twenty hours after inoculation.

The blood was obtained as follows: A rabbit was inoculated with a very small dose of swine-plague bacteria late in the afternoon, and on the following day it was watched very carefully, and just before death would have ensued the animal was etherized and the blood drawn by means of a slender sterilized glass canula inserted into the carotid artery. The blood was collected in large sterile tubes and defibrinated. It was then heated in a water bath for thirty minutes at a temperature of 58° C. Agar tubes were inoculated with the blood before and after the heating. The cultures made from the blood before it was heated showed the swine-plague bacteria to be present in large numbers. Those made after the heating remained invariably clear. The sterilized blood was kept at a temperature of about 8° C. until it was needed for use, when the desired quantity was heated up to the body temperature.

A.—EXPERIMENTS ON RABBITS.

In these experiments the sterilized blood was injected subcutaneously and into an ear vein. The number of injections made, quantity of sterilized blood used, and the results obtained after the test inoculation with the living bacteria are given in the following table:

XV.—Table showing results of experiments with rabbits treated with sterilized blood of swine-plague rabbits.

Date of blood injection.	Mar. 24.	Mar. 28.	Apr. 4.	Apr. 7.	Apr. 10.	Total.	Inoculated with swine-plague bacteria—	Results.
<i>Subcutaneous.</i>								
Rabbit—	cc.	cc.	cc.	cc.	cc.	cc.		
No. 441	1.5	1.5	3	3	3	12	Apr. 19, 1893	Recovered.
No. 446	1.5	1.5	3	3	3	12	do	Do.
No. 443	1.5	1.5	1.5	1.5	.....	6	do	Do.
No. 442 .....	.....	1.5	1.5	3	.....	6	do	Died June 14, pleuritis and pericarditis.
No. 485(control) .....	.....	.....	.....	.....	.....	.....	do	Died April 29, acute swine plague.
<i>Intravenous.</i>								
Rabbit—								
No. 439	1	1.5	1.5	.....	.....	4	Apr. 8, 1893	Recovered.
No. 440	1	1.5	1.5	.....	.....	4	do	Do.
No. 444(control) .....	.....	.....	.....	.....	.....	.....	do	Died Apr. 9.

The immediate effect produced by the injection of the sterilized blood was manifested by a considerable rise of temperature in about three hours after the injection. It soon subsided, however, and no other

symptoms were detected. This was true of the rabbits that were injected both intravenously and beneath the skin. The temperature of the treated rabbits was normal at the time the control animals died. For several weeks these rabbits appeared entirely well. It was then observed that subcutaneous abscesses were forming on different parts of the body. Nearly two months after the check died rabbit No. 442 was found dead. The post-mortem notes of this animal are as follows:

June 14, rabbit No. 442 found dead. It was somewhat emaciated. The abdominal organs were not appreciably diseased. The pleural cavity contained a large quantity of serum, and the pleura (visceral and parietal) was covered with a thick exudate, the deeper layer of which was firmly adherent to it. The heart was incased in a rather thick membranous exudate. Heart muscle pale; blood dark but not clotted. Cover-glass preparations from the exudate contained a considerable number of polar-stained swine-plague bacteria. A tube of bouillon inoculated with the exudate developed a pure culture of swine-plague bacteria.

June 15, rabbit No. 443 was chloroformed. The post-mortem examination showed a slight thickening of the subcutaneous tissue at the point of inoculation. The thoracic and abdominal organs were apparently in a normal condition. No swine-plague bacteria were found in the organs or in the subcutaneous tissue at the point of inoculation.

June 30, 1893. The abscesses beneath the skin of rabbits Nos. 441, 446, 439, and 440 were found to vary from 1 to 4 cm. in diameter. None of them were located at the point of inoculation. Their distribution is best illustrated by referring to No. 439. This rabbit had an abscess, which had ruptured, over the sternum, an abscess as large as an English walnut in the subcutaneous tissue on the right side of the thorax, one beneath the superficial muscle over the right thigh, and one small abscess beneath the skin in the right popliteal space. The abscesses were opened in rabbits Nos. 439 and 448 and found to contain a thick, somewhat viscid, grayish, purulent substance. Tubes of bouillon inoculated from this purulent substance developed into pure cultures of swine-plague bacteria. This localization of the bacteria did not appear to affect the general health of the rabbits. After the abscesses were opened they healed with one exception (one abscess in rabbit No. 439), and the rabbits appeared to be perfectly well. In order to determine whether or not the abscesses were confined to the subcutaneous tissue, these rabbits (Nos. 439 and 440) were chloroformed July 14, and thoroughly examined. No. 439 showed no lesions, but in No. 440 two of the axillary glands were enlarged and found to contain foci of suppuration, and beneath the peritoneum in the lumbar region there was an abscess containing broken-down pus cells and swine-plague bacteria, as determined by microscopical examination. The kidneys were small and firm but free from bacteria, as indicated by cultures. Nos. 441 and 446 were inoculated twice subsequently with a culture of the same virulent swine-plague bacteria without manifesting any general disturbances. For their further history and use see p. 74.

B.—EXPERIMENTS ON GUINEA-PIGS.

A single experiment was made on guinea-pigs with the sterilized blood from the swine-plague rabbits. Two guinea-pigs, Nos. 374 and 377, received subcutaneously 5.25 cc. each of the sterilized blood in 3 doses (March 28, April 4, and April 7). April 18 they were inoculated subcutaneously, together with two control guinea-pigs, with 0.01 cc. each of a fresh bouillon culture of swine-plague bacteria. The check

died in six days. The treated animals remained apparently perfectly well. They were subsequently used for other purposes, but on post-mortem examination they did not reveal the existence of any lesions that could be attributed to the swine-plague bacteria previously inoculated.

GUINEA-PIGS MADE INSUSCEPTIBLE TO SWINE-PLAGUE BACTERIA
OFFER NO RESISTANCE TO HOG-CHOLERA BACTERIA, AND VICE
VERSA.

The difference that exists between the products of hog-cholera and swine-plague bacteria, as shown by the foregoing experiment, is further illustrated by the fact that guinea-pigs that are immune to one disease offer no resistance to the other. From the differences already pointed out between these two species of bacteria this condition would be expected, and consequently only one experiment has been made with each.

Guinea-pigs Nos. 1 and 2, that had been immunized against hog cholera by subcutaneous injections of sterilized bouillon cultures, were inoculated with 0.01 cc. of a bouillon culture of virulent swine-plague bacteria. They died on the third day with the control animal. One of these guinea-pigs (No. 2) had been twice inoculated with hog-cholera bacteria.

Guinea-pigs Nos. 374 and 377 were made resistant to the fatal effect of swine-plague bacteria by subcutaneous injections of sterilized defibrinated blood from swine-plague rabbits. They were subsequently inoculated with 0.1 cc. of a bouillon culture of virulent hog-cholera bacteria. They lived one and two days respectively longer than the control, which died in an unusually short time. The lesions found upon examination were those characteristic of acute hog cholera. The variations found to exist in the length of time required for 0.1 cc. of a bouillon culture of hog-cholera bacteria to kill guinea-pigs render the short time these animals lived after the control died of no significance, especially as there were no variations in the lesions to indicate increased resistance.

PROTECTIVE ACTION OF BLOOD SERUM FROM IMMUNE RABBITS.

According to Metchnikoff a comparatively small quantity of blood serum from immunized animals is sufficient to induce immunity in rabbits. It will be remembered that while he asserts this for hog-cholera bacilli he was actually working with swine-plague bacteria. As small a quantity as 0.5 cc. of serum from immunized rabbits injected subcutaneously was sufficient to protect a rabbit from a quantity of virulent blood sufficient to kill a control rabbit. Injection of serum into the circulation directly was much less efficacious.

The following experiment fully confirms Metchnikoff's work if, as has

been stated above, we substitute the words swine plague for hog cholera in his article. The serum was obtained from rabbits Nos. 441 and 446 made immune with sterilized defibrinated blood of rabbits affected with swine plague and referred to on page 72.

These rabbits were reinoculated with swine-plague bacteria as follows:

June 24, 1893. Nos. 441, 446, and a control receive subcutaneously 0.12 cc. of a bouillon culture three days old.

June 25. Control dead this morning. The others apparently unaffected.

December 5, 1893. Nos. 441, 446, and a control received subcutaneously 0.12 cc. of a bouillon culture (the same stock culture) twenty-four hours old.

December 6. Control dead.

December 7. No. 441 has a temperature of 102° F.; No. 446, 101° F.

December 12. No. 441 has a temperature of 102° F.; No. 446, 101.4° F.

No. 446 was etherized and bled from a carotid January 4, 1894, thirty days after the last inoculation. All the blood obtainable was collected and the animal allowed to die while anæsthetized. It was very thin at this time. In the lungs there were in all five foci of disease in which the lung tissue was converted into a necrotic mass containing large numbers of pus cells and many polar-stained bacteria. In the bronchi and trachea a considerable quantity of muco-purulent material containing not the polar-stained bacteria but small cocci deeply stained, in masses and mainly within pus cells. The lung lesions where they reached the pleura had produced an exudate attaching the lungs to the chest wall by means of still soft, easily broken adhesions.

The cause of these lung lesions was not definitely determinable. At first thought the subcutaneous inoculation thirty days ago appeared responsible, but the location of the disease did not harmonize with this supposition. Usually the pleura is involved first and very extensively, and the lungs only secondarily by contiguity. Furthermore, the bacteria present appeared slightly larger than those injected and were very much attenuated, so that it required a comparatively large intravenous dose to destroy a rabbit. Parallel bouillon cultures of this bacillus differed quite markedly in appearance from those of the swine-plague bacillus originally injected.

The more probable supposition appeared to be that this rabbit was infected through the air passages with the bacillus of rabbit septicaemia* or influenza recently investigated by one of us in this laboratory, which bacillus resembled the one from rabbit 446 closely, both in cultures and in pathogenic activity.

Rabbit No. 441 was bled to death under ether January 8. This animal was in good condition and no internal lesions were found.

* Moore and Kilborne: An outbreak of rabbit septicaemia, with observations on the nature of the disease and its specific organism. *American Veterinary Review*, 1893, Vol. xvii, p. 285.

Cultures from spleen and liver remained sterile. The serum was used as indicated in the subjoined table:

XVI.—Table showing results of protective action of blood serum.

Blood from	No. 446.	No. 441.							Inoculated with 0.06 cc. virulent bouillon culture.	Result.
When drawn	Jan. 4.	January 8.								
Date of injection of serum	Jan. 5.	Jan. 9.	Jan. 10.	Jan. 11.	Jan. 12.	Jan. 13.	Jan. 15.	Total.		
Rabbit—	cc.	cc.	cc.	cc.	cc.	cc.	cc.	cc.		
No. 120	0.9	1	1	1	0.5	0.5	3.9	Jan. 19.	Recovered.	
No. 121	0.5	0.9	1	1	1	0.5	5.4	Jan. 19.	Dies Feb. 5.	
No. 130				1	1.5		2.9	Jan. 19.	Dies Feb. 12.	
No. 129 (control)								Jan. 19.	Dead in 20 hours.	
Guinea-pig—										
No. 39					1.3	1.0	0.75	3.05	Jan. 19.	Recovered.
No. 40					1.3	1.0	0.75	3.05	Jan. 19.	Dead Jan. 30.
No. 41 (control)									Jan. 19.	Dead Feb. 1.

The subsequent history of the three treated rabbits and the guinea-pigs is briefly told.

No. 121. January 22, three days after the test inoculation, the temperature was 103.3. A local swelling was noticed, about one-half inch in diameter and one-eighth inch thick.

January 24.—Temperature, 102.5. Local swelling larger, 1 inch across at base, one-half inch thick.

January 29.—Lesion as before. Up to to-day this rabbit has been eating, moving about, and playful.

February 5.—Rabbit dies very unexpectedly to-day. It was still playful this morning. The autopsy showed that the abscess at the place of inoculation had gradually destroyed the abdominal wall over an area one-fourth of an inch in diameter. The contents of the abscess, protected only by the peritoneum, projected into the abdominal cavity as a conical mass. The swine-plague bacteria had penetrated this delicate barrier and produced a fatal peritonitis. The viscous exudate contains immense numbers of swine-plague bacteria and a small number of leucocytes. Phagocytosis absent. The bacteria from this partly immune rabbit had not been attenuated. An inoculated rabbit died within 20 hours.

No. 120. On January 22, swelling 1 inch at base, one-half inch thick. Temperature, 102.2.

January 24.—Swelling much larger. Temperature, 102.9.

January 24. Swelling as large as a hen's egg. Up to date this rabbit has been more quiet than No. 121.

March 1. Rabbit now fully recovered. Weight has fallen from 2.5 to 2 pounds. On March 28, a slight gain in weight.

May 15. Has steadily increased in weight.

No. 130. On January 22, temperature 103.4. Swelling like that of No. 120.

January 24. Swelling larger. Temperature, 104.2.

January 29. Swelling as before. Skin breaking. This animal appears quiet but not sick.

February 12. Rabbit dies quite suddenly to-day, though apparently well for a week. Local lesion almost healed. No lesions referable to swine plague excepting perhaps a slightly roughened, opaque condition of the serous covering of cæcum.

The experiment with the guinea-pigs did not give any clear results, as is shown in the table. No. 40 died January 30 with exudative pleuritis and markedly hyperæmic lungs. The control died two days later

with same lesions. In both the exudate contained immense numbers of swine-plague bacteria. The third guinea pig (No. 39) recovered, but did not appear to thrive. It was chloroformed two months after the test inoculation, but no lesions were discovered. This equivocal outcome thus opens the question whether perhaps the immune rabbit's serum is less efficacious when used upon some other species, such as guinea-pigs, than when used on the same species; for the results obtained with rabbit's serum on rabbits are strikingly positive.

DOES THE BLOOD SERUM OF IMMUNE RABBITS POSSESS ANY BACTERICIDE OR ANTITOXIC POWER?

The following experiment was tried with the blood serum of No. 441:

To a given quantity, 0.6 cc., was added a small quantity of a bouillon culture twenty-four hours old, equivalent in amount to one-tenth of the blood serum. This mixture was injected subcutaneously. The experiment is tabulated below:

XVII.—Table showing results of injection of mixture of blood serum and bouillon culture.

Rabbit—	Serum mixture contains—		Age of mixture when injected subcutaneously.	Result.
	Bouillon culture swine plague.	Serum.		
No. 474 (5½ pounds).....	cc. .066	cc. 0.6	10 minutes.....	Dies in 24 hours.
No. 119 (3 pounds).....	.066	0.6	5 hours	Dies in 60 hours.
No. 118 (3 pounds, control).....	.066	0.6 sterile bouillon.	.....	Dies within 20 hours.

In the rabbit receiving the serum mixture five hours old the disease was markedly retarded. On the following day, when the other rabbits were dead, it was quite active and ate its food as usual. On the second day the temperature had risen to 107.6° F. On the morning of the third day it was found dead. The bacteria had not been modified in this rabbit, for a minute, subcutaneous dose from a culture was fatal to a rabbit in 20 hours.

CONCLUSIONS.

The preceding observations and experiments have led to a few well-defined results, which we wish to summarize briefly. The hidden, underlying, vital processes, according to which these results may be interpreted, are either matters of controversy or else wholly intangible as yet. We content ourselves, therefore, in pointing out the more gross, incontrovertible facts elicited, leaving the discussion of subtler problems and the citation of the mainly controversial literature for the present untouched.

Immunity defined as a resistance to the invasion and multiplication of pathogenic bacteria within the body is, when compared with susceptibility, a condition of degree rather than of kind. There are various degrees of immunity producible by one or the other of the methods

employed in these experiments, and in speaking of immunity experimentally produced it is necessary to state precisely the conditions under which such immunity is manifested. Thus a rabbit may be treated so as to resist successfully a fatal injection of swine-plague bacteria into the subcutaneous tissue. The same injection into the abdominal cavity or into the circulatory system may result in speedy death. Continued preventive treatment may indeed finally result in resistance to even these fatal doses. Our experiments have not been pushed to these extremes, and we are therefore unable to state whether, for instance, rabbits may be brought to this high level of immunity without a permanent injury to the organs and tissues, which injury manifests itself in the lower stages of the immunizing process by more or less prolonged emaciation. In the work before us the highest degree of immunity sought for in rabbits and guinea-pigs towards the bacteria of swine plague and hog cholera was a permanent resistance to those minimum doses of culture material which result fatally when injected under the skin of untreated animals.

The various processes we have employed in the production of immunity may be classed as follows:

- (a) The use of attenuated cultures of living bacteria.
- (b) The use of sterilized bouillon cultures.
- (c) The use of sterilized bouillon suspensions of bacteria from agar cultures.
- (d) The use of sterilized blood from animals in the last stages of the fatal inoculation disease.
- (e) The use of blood serum from susceptible animals in which a certain degree of immunity had been produced by one or the other of the foregoing methods.

These five processes may be ranged under three main heads:

- A* (including *a*). The use of living bacteria.
- B* (including *b*, *c*, *d*). The use of the chemical products of bacteria.
- C* (including *d*, *e*). The use of certain still undefined substances in the blood, variously called antitoxins, alexins, etc.*

It may be that all of the methods given will be ranged, after more exhaustive investigations, under bacterial products, a view even now maintained by Büchner.† The relative efficiency of these processes is not precisely the same for both diseases experimented with, and for this reason, as well as for the sake of greater clearness, the result obtained with each species is best summarized by itself and comparisons made subsequently.

HOG CHOLERA.

If we compare the protective action on rabbits we shall find that of all the methods, the use of living, attenuated cultures was the only one which led to success. Even with this method the failures were many because the vaccinal doses were often too great or the culture of too high a degree of virulence. Rabbits are so susceptible to hog-cholera

* *d* is included under *B* and *C*, because it is proper to assume that in the blood of sick animals we have antitoxins as well as bacterial products present.

† Münchener med. Wochenschrift, 1893, Nos. 24, 25.

bacteria that their immunization requires, as has been shown in the text, not less than two preventive inoculations at an interval of one or more months. It is not to be denied that immunity may be produced with the use of sterilized agar suspensions, sterilized blood of diseased rabbits or blood serum from immune rabbits, but these methods as applied by us made no impression on rabbits whatever. When applied in the same way in swine plague they produced a high degree of resistance.

The less susceptible guinea pig reacted somewhat differently. Immunity was brought about with sterilized bouillon cultures but with varying results. Living attenuated cultures were not tried. Sterilized agar suspensions produced a slight retardation of the disease while sterilized blood from diseased guinea-pigs failed to produce any impression. A slight retardation of the disease was also produced by the blood serum of immunized guinea-pigs but no retardation was noticed when the blood serum from immunized rabbits was used.

SWINE PLAGUE.

A greater or less degree of immunity was produced in rabbits by sterilized bouillon cultures, sterilized agar suspensions, sterilized blood from infected rabbits, and blood serum from immunized rabbits. Experiments on guinea-pigs were restricted to two methods. The sterilized blood of diseased rabbits was capable of producing immunity while the blood serum of immune rabbits produced rather equivocal results, as Table XVI shows.

In the following table those experiments are marked with the sign + in which more or less immunity was produced, and those with the sign — in which no appreciable resistance was noticed. Even those in which only a distinct retardation of the fatal issue was produced are considered positive, for it is fair to assume that such retardation would have become immunity if the treatment had been pushed a little further:

Immunizing processes employed.	Rabbits.		Guinea-pigs.	
	Hog cholera.	Swine plague.	Hog cholera.	Swine plague.
Repeated injection of living attenuated cultures.	+			
Sterilized bouillon cultures....	—	+ (16 cc. in 5 injections, ear vein.)	+ (10 cc. in 4 injections, 8 cc. in 8 injections.)	.....
Sterilized suspensions of agar cultures.	—	+ (7-8 cc. in 4 injections, abdomen.)*	Very slight effect.	.....
Sterilized blood of rabbits in last stage of disease.	—	+ (6 cc. in 4 injections, subcutis.)	—	+ (5 cc. in 3 injections, subcutis.)
Sterilized blood of guinea-pigs in last stages of disease.			—	
Blood serum from immunized rabbits.	—	+ (4 cc. in 5 injections, subcutis.)	Doubtful.....	Doubtful.
Blood serum from immunized guinea-pigs.			+ (5 cc. in 5 injections, produced retardation).	.....

* Immunity produced in some cases with smaller doses. See Table XIV.

The experiments on swine with suspensions of agar cultures of hog-cholera bacilli demonstrate that immunity toward a fatal intravenous dose may be produced. Unfortunately no opportunity was offered to test the behavior of pigs protected in this way when exposed to the natural disease on the farm. The cost of preparing the sterilized suspensions would be a decided objection to their employment on a large scale.

We are well aware of the fact that only a beginning has been made by us in the study of experimental immunity with reference to these two important animal disease germs. A continued investigation of the collateral problems which have presented themselves in the course of the work is highly desirable, especially in the direction of seeking an answer to the question, why some species of animals are very susceptible, others only partially so, to the same pathogenic bacteria.

The definite progress made in this work is illustrated by the following important determinations:

1. It is possible to produce immunity toward hog-cholera and swine-plague bacteria in the very susceptible rabbit and the less susceptible guinea-pig. In the rabbit the only promising method of immunization toward hog cholera is the use of gradually augmented doses of attenuated cultures.

2. Immunization toward swine-plague bacteria is produced artificially with much greater ease than toward hog-cholera bacteria.

3. The blood serum of animals protected against hog cholera and swine plague is almost as efficacious in producing immunity soon after treatment as the bacterial products obtained from cultures.

4. Different degrees of immunity in both hog cholera and swine plague lead to different forms of the inoculation disease. The greater the immunity short of complete protection the more prolonged and chronic the disease, induced subsequently by inoculation.

5. Pathogenic bacteria may remain in the organs of inoculated animals some time after apparently full recovery. Their presence may or may not be associated with lesions recognizable by the naked eye.

6. The toxicity of sterilized cultures appears to be directly proportional to the number of bacteria in the injected fluid.

7. The results of Selander and Metchnikoff in the immunization of small animals were obtained with swine-plague and not with hog-cholera bacilli.

ON THE VARIABILITY OF INFECTIOUS DISEASES AS ILLUSTRATED BY HOG CHOLERA AND SWINE PLAGUE.

By THEOBALD SMITH and VERANUS A. MOORE.

The ideas incorporated in this article date back a number of years and owe their origin to the work on swine diseases carried on since 1885.

The first intimation of any variation in the virulence of bacteria from swine diseases was obtained by the isolation of swine-plague bacteria from different outbreaks.* Some of these varieties produced in rabbits after subcutaneous inoculation an exudative peritonitis fatal within a week. Others produced a septicæmia fatal within twenty-four hours.

In 1889 one of us pointed out the difference in the lesions produced in rabbits by the inoculation of two distinct varieties of hog cholera.†

Out of these observations grew the question whether these bacteria, morphologically and biologically identical, must be considered as different because of the different degrees of pathogenic power manifested by them. A long series of inoculations into rabbits made in 1889 with two hog-cholera bacilli of different virulence showed that the diseases induced by them could be made the same either by reducing the virulence of one of the varieties or increasing the resistance of the inoculated animal. The same was demonstrated by a preliminary experiment with virulent swine-plague bacteria in 1889.‡

The continuation of the investigations on preventive inoculation has enabled us to collect a considerable amount of information illustrative of variations in the gross manifestation of disease which may be brought about experimentally. This information we deem of great importance toward the proper understanding of infectious diseases as a whole, and hence present it here in as compact a form as possible.

* See Report on Swine Plague (1891) for a description of these bacteria.

† Bacillus *a* and Bacillus *z*, pages 9 and 13. See also the New York Medical Journal 1890—ii, p. 485.

‡ Report on Swine Plague, p. 148.

SWINE PLAGUE.

Among the forms of disease which we have observed after the subcutaneous inoculation of rabbits with swine-plague bacteria from different sources are the following:

1. Septicæmia.
2. Peritonitis.
3. Pleuritis (usually with pericarditis).
4. Pleuritis (usually with pericarditis) and peritonitis.
5. Local lesion only.

In the septicæmia death ensues within eighteen to twenty-four hours. The local lesion produced at the seat of inoculation is slight. Bacteria are abundant in the parenchyma (blood vessels) of the various organs. In the form characterized by peritonitis death ensues in three to seven days. The local lesion, which in all these forms of disease increases in extent with the prolongation of the life of the animal, is here characterized by more or less suppurative infiltration of the skin and the subcutis. The peritonitis in its earlier stages is characterized by punctiform hemorrhages on the cæcum and an exudate varying in character, being fibrinous or cellular. It always contains immense numbers of bacteria. When pleuritis is also present the exudate usually involves the pericardium as well. It varies in amount according to the duration of the disease and is essentially the same as the peritoneal exudate.

The form characterized by pleuritis and pericarditis without peritonitis is interesting in so far as the seat of inoculation does not explain the localization, for, in every case, the inoculation was made in the region of the abdomen. The lungs may become hepatized secondarily through invasion from the pleura if the animal lives long enough.

Lastly, the form of disease in which the only localization is a very extensive suppurative infiltration associated with hemorrhage and œdema of the subcutaneous tissue is not common.

It should be stated that the cultures from the same outbreak continued to produce the same form of disease in rabbits until modified by age. The maintenance of a certain uniform virulence for years is well exemplified by a variety isolated in the summer of 1890.* This variety was fatal to rabbits within twenty hours when first isolated, and this degree of virulence has maintained itself up to the present, a period of nearly four years.

Inasmuch as numerous illustrations of these forms of swine-plague in rabbits may be found in the report on swine-plague and in the reports of the Bureau of Animal Industry since 1886, we refrain here from citing any cases.

* Bulletin on Swine Plague, p. 57.

MODIFICATIONS OF THE SEPTICÆMIA TYPE BY INCREASING THE RESISTANCE OF RABBITS.

By the various processes recorded in the preceding article which increase the resistance of rabbits we have been able to produce nearly all the pathological variations which follow the inoculation of natural races of swine-plague bacteria as isolated from outbreaks. This modification of the septicæmia type is not fortuitous, for among the large number of rabbits inoculated during the past three and one-half years with the culture employed none have survived twenty to twenty-four hours. Whenever the course of the inoculation disease in rabbits departed from this rapidly fatal type it was due to some preliminary treatment of the rabbit.

The degree of resistance determined quite regularly though not invariably the form of the disease. This degree was measured by the relative quantity of the protective material (sterilized cultures, sterilized blood, and blood serum) injected. The grades of disease induced range themselves in the following order:

1. No resistance—acute septicæmia.
2. Slight resistance—peritonitis.
3. Increased resistance—pleuritis and pericarditis with or without secondary pneumonia.
4. Higher degree of resistance—pleuritis and peritonitis.
5. Still greater resistance—irregular lesions in the form of abscesses, subcutaneous and subperitoneal.
6. Nearly complete immunity. Very slight reaction at the point of inoculation.

Most of the cases cited below as illustrating these modified forms of the septicæmia type belong to the series of immunizing experiments of the preceding article. To this the reader is referred for additional illustrations.

First degree of resistance—peritonitis.—Rabbit No. 12 received 7 cc. of bouillon culture of swine-plague bacteria sterilized by heat. Subsequently with a control rabbit it was inoculated with a minute dose of swine-plague bacteria under the skin. The control died within eighteen hours, the treated rabbit in three days. The macroscopic changes were limited to the point of inoculation and the peritoneum. At the former there was a purulent infiltration of the subcutis, 1.5 cm. in diameter, with dilatation of surrounding blood vessels. The peritonitis was characterized by an exudate of a slightly viscid character covering liver, spleen, and cæcum, and made up of fibrin, leucocytes, and immense numbers of bacteria.

Second degree of resistance—pleuritis and pericarditis.—Rabbit No. 38* was treated before inoculation with 4.5 cc. of a sterilized suspension of agar cultures of swine-plague bacteria in 3 doses. Together with a control rabbit, it received under the skin the equivalent of 0.001 cc. of a fresh bouillon culture of swine-plague bacteria. The

* See Bulletin on Swine Plague, p. 148, for the entire experiment tabulated.

control died in twenty hours. The treated rabbit died six days after inoculation. At the point of inoculation there was a purulent infiltration of the subcutis 3 cm. in diameter. The abdomen and abdominal viscera were free from macroscopic changes. In the thorax, the pleural cavity was lined with a grayish, friable exudate consisting of round cells and bacteria. Lungs hyperæmic and only partly collapsed. Pericardium also covered with a slight exudate.

Third degree of resistance—pleuritis (pericarditis) and peritonitis.—Rabbit No. 15 received in the ear vein 12 cc. of a sterilized bouillon culture of swine-plague bacteria. It was inoculated subcutaneously with virulent swine-plague bacteria May 26, and died June 3, eight days later. The control rabbit died within eighteen hours. The following changes were observed:

A purulent infiltration into the subcutaneous tissue at the point of inoculation extending over an area 6 cm. in diameter. The superficial layer of the subjacent muscle discolored. Surrounding the area of infiltration the blood vessels were injected. The cæcum and liver were covered with a very thin grayish exudate, which also appeared on and between the coils of the intestine. Spleen not enlarged.

The right lung and chest wall covered with a thin grayish exudate. In the cephalic lobe, two small areas of consolidation; principal lobe hyperæmic. The left pleural cavity lined with a quite thick membranous exudate, which covered the entire surface of the lung. On the dorsal surface of the principal lobe a mass of lung tissue 2 cm. in diameter, firm and of a yellowish-gray color. The remaining portion of the principal lobe hyperæmic; cephalic lobe in state of collapse.

Pericardium covered with a thin cellular exudate.

Higher degrees of resistance.—None of the treated animals which have come under our observation, have succumbed to a mere extension of the lesion produced at the point of inoculation as is occasionally observed after inoculation with certain varieties of swine-plague bacteria found in nature. There have been noticed, however, certain peculiar localizations resembling those produced in the subcutis after inoculation, and in a few cases the local lesion persisted a considerable length of time. It was quite severe in all fatal cases in which the disease was prolonged several weeks after inoculation, although the real cause of death was due in all such cases to localizations on one or more of the serous membranes. The peculiar forms of disease may be grouped as follows:

(a) *Persistence of local lesion.*—Rabbit No. 50 received in the abdominal cavity 3.5 cc. of the sterilized suspension of agar cultures in 3 doses. It was subsequently inoculated beneath the skin with 0.001 cc. of a bouillon culture of swine-plague bacteria which produced a large local swelling. On February 25, 1892, nearly eight months after its inoculation, it was chloroformed. The only lesion found was in the subcutaneous tissue. At the point of inoculation the skin was sloughed over an area 3 cm. in diameter. This denuded surface was covered with a thick scab. The subcutis beneath the scab and surrounding the ulcer was infiltrated with pus. A stained cover-glass preparation showed swine-plague bacteria. No other lesions were found.

(b) *Sub-peritoneal abscess.*—Rabbit No. 16 was injected intravenously with 16 cc. of sterilized bouillon cultures of swine-plague bacteria. After some days it was inoculated beneath the skin with 0.001 cc. of a fresh bouillon culture of virulent swine-

plague bacteria. The control rabbit died within twenty hours. Rabbit No. 16 showed no ill effect from the inoculation for several months when it was noticed that it was becoming emaciated. It died June 11, 1892, one year and six days after its inoculation with an enormous subperitoneal tumor, which is described on page 67.

(c) *Multiple abscesses under the skin.*—Rabbit No. 439 received into the ear vein in 3 injections 4 cc. of sterilized blood from a swine-plague rabbit. Later it was inoculated subcutaneously with 0.001 cc. of a bouillon culture of virulent swine-plague bacteria. The control rabbit died within twenty hours. Two months after the inoculation it was noticed that this rabbit with others was suffering from a large number of subcutaneous abscesses, described on page 72.

HOG CHOLERA.

The lesions produced in rabbits after subcutaneous injection of the most virulent variety of the hog-cholera bacillus (the one most frequently encountered) have been given on page 10. The lesions produced by the less virulent varieties may either resemble these on intravenous inoculation or else they may be quite different both after subcutaneous and intravenous inoculation. That variety of the hog-cholera bacillus described as ζ on page 13 presents some striking differences, to which reference has already been made by various illustrative cases. In the illustrations given below the macroscopic changes in those animals which succumbed to a more prolonged chronic illness were concentrated in the follicular apparatus of the intestines and the lungs.

Modified disease produced in a rabbit with hog-cholera bacilli attenuated by heat.—The culture used had been exposed for thirty-eight days to 43.5° C. to 44° C., according to the procedure described on page 42. The rabbit received subcutaneously 0.12 cc. of a fresh bouillon culture twenty-four hours old. It died in twenty days. The temperature during the disease remained rather low, fluctuating between 103° and 104° F. On the fourteenth day it began to sneeze and cough and a few days later a muco-purulent discharge from the nose appeared. On the twentieth day it was unable to get up and was chloroformed. The lesions were in brief as follows:

At the point of inoculation a small abscess; spleen moderately enlarged; liver free from necroses; the bunch of lymph glands at root of mesentery as large as a horse chestnut and mottled with whitish foci; the Peyer's patches at ileo-caecal valve are thickened; the follicles very large, whitish; the overlying mucosa ulcerated; the lungs were also involved; the entire right ventral and a portion of the right cephalic lobe involved in broncho-pneumonia; the left principal lobe is solid, dark red on section; the air passages contain a thick muco-pus.

Portions of an ulcerated Peyer's patch, of the enlarged mesenteric glands, and of the lungs hardened in alcohol were submitted to microscopic examination. The follicles and the follicular tissue of the Peyer's patch owe their swollen condition to leucocytic infiltration in the depths of which a few clumps of hog-cholera bacilli are brought out by methylene blue. In the gland the whitish foci were found to be collection of leucocytes, largely broken down, in which are embedded clumps of bacilli. The pneumonia was characterized by dense cell infiltration of alveoli and small air tubes with desquamation of cells in the alveoli around the broncho-pneumonic foci.

A rabbit was inoculated subcutaneously with 0.5 cc. of a culture of the hog-cholera bacillus exposed to 43.5° to 44° C. for one hundred and ninety-five days. Rabbits inoculated at the same time with smaller doses survived, while this one died, very much emaciated, in thirty-seven days. The local lesion was encysted, and the only other changes consisted of twelve infiltrated follicles in the appendix and about six similarly affected follicles in the Peyer's patches in ileum and cæcum, near the valve. The mucosa overlying the cæcal patch shows two excavated ulcers with irregular edges.

A rabbit was inoculated by injecting 0.12 cc. of peptone bouillon culture into an ear vein. The bacilli used were from the culture described as β (page 10), and at the time of injection nearly seven years old. The attenuation was thus due to prolonged cultivation. The rabbit succumbed in four days. Besides the usual parenchymatous changes, there had developed a pneumonia, involving the right ventral and azygos lobe in hepatization. The trachea and bronchi contained much catarrhal exudate.

The lesions produced by the inoculation of virulent material into rabbits, in which a partial immunity has been induced are similar to those produced by attenuated cultures in rabbits having no artificial protection. This is well illustrated by the following case:

Rabbit No. 13. June 12, 1889, receives subcutaneously 0.05 cc. bouillon culture of virulent hog-cholera bacilli exposed to 43.5° to 44° C. for ninety-eight days. The temperature rose to 106.8° F. four days after inoculation and fell to normal in two weeks.

July 16. Subcutaneous inoculation of 0.05 cc. unattenuated culture.

October 1. Subcutaneous inoculation with a particle of spleen pulp from a rabbit.

December 14. Found dead to-day. The lesions are very interesting as compared with acute hog cholera.

Intestines.—Much mucus present in small and large intestines. Peyer's patch in cæcum near valve infiltrated and on the mucous surface converted into a yellowish brown slough. In the cæcum itself along the mucous folds are groups of slightly depressed firm sloughs of the mucosa. Similar ulcers in upper portion of colon. In the appendix all the follicles are whitish and more or less swollen, some 4 to 5 mm. in diameter and projecting into lumen of tube. Mucosa not necrosed.

Spleen large, dark, and soft. Liver dotted with a considerable number of grayish spots. The presence of coccidia makes their nature doubtful. On the surface of both kidneys there are 50 to 75 firm nodules, variable in size, the largest being 4 mm. in diameter and projecting hemispherically above the surface. They dip down into cortex as elongated masses of a caseous appearance and firm consistency.

The lungs remain fully expanded on opening thorax. With the exception of a narrow border on cephalic lobes they are completely hepatized. The surface, of a bright red color, is beset with pale yellowish irregular spots 1 to 4 mm. in diameter. These spots are not well defined, but surrounded by a hazy nebulous border. They correspond to nodules in the lung tissue which are of a cheesy consistency and crumble on pressure.

In sections of hardened tissue the lung is found containing necrotic foci surrounded by a zone of alveoli filled with round cells and more or less new connective tissue.

The hog-cholera bacillus was still present in the spleen. A colony from an agar culture produced the characteristic acute fatal disease in rabbits. Any attenuation of the bacillus not noticeable.

The localization of hog-cholera bacilli, injected into the circulation, in the brain substance, and the production of a focus of necrosis and suppuration, is illustrated by the rabbit referred to on page 43 of this bulletin. In this case macroscopic changes in other organs were not detected.

A FORM OF PSEUDO-TUBERCULOSIS PRODUCED IN RABBITS AND GUINEA-PIGS AS A RESULT OF INCREASED RESISTANCE OF THE ANIMALS OR ATTENUATION OF THE VIRUS.

A.—GUINEA-PIGS.

This form of inoculation disease was first noticed in guinea-pigs in 1890. The resistance of the guinea-pigs had been increased by various methods. Some of them survived the inoculation of the usually fatal dose of hog-cholera bacilli. Others succumbed to a prolonged disease, during which the pseudo-tubercles to be described were formed.

These tubercles situated, as a rule, in the subserous tissue of the abdomen and under the pulmonary pleura, are small, slightly convex bodies of a whitish or neutral gray color. In form they are roundish or slightly elongated. In size they vary from barely recognizable dots to bodies 2 mm. in diameter. They are firm in consistency and give the sensation of hard, granular bodies. In appearance they are strikingly like the true tubercles when the latter are situated on the serous membranes. In fact when they were first noticed it was thought that the guinea-pig had been inoculated accidentally with tuberculous material.

In sections, cut by the paraffin method, these bodies were found to consist of aggregations of round cells of which the central portion was largely disintegrated. No limiting membrane, stroma, or giant cells have been found. When crushed with forceps and examined under the microscope in a fresh condition cells more or less degenerated are the only tissue elements observable. In properly stained cover glass preparations made from the crushed bodies hog-cholera bacteria were found in considerable numbers. Similar preparations from the blood, spleen, and liver of the same animal failed to show them.

These pseudo-tubercles were almost always present in guinea-pigs which lived four or more days longer than the control animals. In a similar series of experiments made by Dr. E. A. de Schweinitz in 1890 with substances isolated from pure cultures of hog-cholera bacteria the pseudo-tubercles were found when an increased resistance equivalent to only one or two days had been induced.*

In the experiments to test the immunizing efficacy of sterilized cultures of hog-cholera bacteria (p. 46) thirteen guinea-pigs died in four or more days after the control animals. In nine of these the pseudo-tubercles were found.† It is of interest to note that in a few guinea-pigs

* Medical News, October 4, 1890.

† For the history of the four other guinea-pigs (Nos. 477, 19, 478, and 438), see p. 47.

that were killed for examination several months after inoculation the tubercle-like bodies were not found.

The distribution* of the pseudo-tubercles in the body of the guinea-pigs varied considerably in the different animals. They were either quite generally distributed beneath the serous membranes or confined within circumscribed areas, where they came into actual contact one with another or were separated by a distance of from 0.5 to 3 mm. The localities in which they have been found, beginning with the most common, are as follows:

1. Beneath the peritoneum, more especially along one side of the spinal column or else aggregated in limited areas from 3 to 5 cm. in diameter. When separated by only a short distance the nodules were frequently connected by delicate grayish lines.

2. In the heart muscle.

3. Beneath the pleura of diaphragm and lungs.

4. In the mesentery.

5. In or beneath the fascia covering the abdominal wall.

The Malpighian corpuscles in the spleen were frequently enlarged, so that they resembled the pseudo-tubercles very closely.

In addition to the pseudo tubercles there were a few other lesions not usually found in the control animals which indicate a further change in the course of the disease. These variations usually accompany the development of pseudo-tubercles, although they may appear in a less marked form in animals that die presumably before the nodules beneath the serosa are formed. The most important of these variations are as follows:

- (a) The purulent infiltration into the subcutaneous tissue at the point of inoculation was less severe than in the control animals.

- (b) The areas of necrosis in the liver were less marked, but there was observed a diffuse fatty degeneration of the parenchyma.

- (c) The enlargement of the spleen was less marked and the color more normal.

- (d) The inguinal and knee-fold lymph glands were more enlarged and the follicles in Peyer's patches more frequently infiltrated.

- (e) A membranous exudate was usually noticed over the spleen and liver, frequently accompanied with effusion of serum into the peritoneal and pleural cavities.

B.—RABBITS.

An eruption of tubercle-like bodies was produced on the peritoneum in rabbits by the intraabdominal injection of hog-cholera bacilli attenuated in mixed cultures. The lesions are best described by a case:

February 10, 1891. Two rather small rabbits inoculated with the attenuated hog-cholera culture, one receiving 0.2 cc. subcutaneously, the other 0.15 cc. into abdomen. The former showed no indications of disease at any time; the latter died in nine days.

The autopsy revealed in the abdomen on ventral walls beneath serosa a large number of whitish, slightly elevated, roundish tubercle-like

* For cases illustrating the occurrences of these nodules, the reader is referred to the post-mortem notes of guinea-pigs Nos. 3, 10, 13, 17, and 18 on page 47.

bodies 1 to 1.5 mm. in diameter. They are also present in large confluent patches on serosa of cæcum. The Peyer's patches of intestines are infiltrated, the mucosa eroded over some of them. The mesenteric and retro-peritoneal lymph glands contain whitish suppurative foci. In the liver are disseminated numerous minute foci of necrosis. Heart and lungs normal. Some of the tubercles are easily teased out of their surroundings. When broken up, rubbed on cover glasses, and stained numerous mononuclear cells and a considerable number of hog-cholera bacteria appear. In sections of hardened tissue these tubercles appear as a collection of cells under serosa, the center of which shows extensive fragmentation of nuclei. Giant cells are not seen. In the center of many of these foci clumps of hog-cholera bacilli are located. Cultures from this case were plated, and on March 4 a large black rabbit receives into abdomen 0.1 cc. of a bouillon culture twenty-four hours old made from a colony. It was found dead March 13 and showed the following peculiar lesions:

Thorax.—Heart somewhat dilated. Fatty degeneration of walls. Under serosa of lungs very minute translucent tubercles. On tip of right ventral lobe, which is hyperæmic, several large, opaque, whitish tubercles.

Abdomen.—Diaphragm and mesenteries sprinkled with very many minute opacities. On serosa of stomach barely visible tumefactions or tubercles. On spleen a large number of minute grayish tubercles. On liver many barely visible whitish points. Follicles of Peyer's patches infiltrated, mucosa necrosed. The same is true of follicles in appendix of cæcum. Scattering patches of necrosis in cæcum. Suppurative foci in mesenteric glands. Kidneys large with marked parenchymatous degeneration of cortex and cyanotic appearance of medulla. From this case also the injected bacilli were isolated from the spleen.

The foregoing experimental observations lead to certain important deductions, which throw light not only on the subject of preventive inoculation but also on the interrelation of certain groups of infectious diseases.

We have seen that there are certain varieties of the same species of pathogenic bacteria in nature which produce different types of the same disease when inoculated into susceptible animals. We have also seen that the disease produced by the most virulent variety may be so modified by increasing the resistance of the animal as to resemble the various types produced by the more attenuated natural varieties. Lastly, we have demonstrated that some of the types of the inoculation disease as observed in partly immunized animals may be reproduced in fully susceptible animals by the inoculation of an artificially attenuated culture. This relation between the degree of virulence of certain bacteria on the one hand and the relative resistance of the animal body on the other may be expressed by the simple formula—

$$d = \frac{v}{r}$$

in which v = virulence, r = the degree of resistance or immunity of the animal, and d = the type of disease. By changing either virulence

or resistance the type is changed. When we reduce the virulence we obtain about the same disease as when we leave the virulence unchanged and increase the resistance of the animal by some kind of preventive treatment, i. e., the value of d remains the same.

Somewhat similar statements have been recently made by Charrin* concerning the pyocyaneus infection in rabbits. He notes much variation in the lesions of any one set of organs, such as the kidneys. His observations, however, pertain more to histological changes, whereas our facts bear on the distribution of macroscopic lesions over the entire body. Charrin injects into an ear vein and thereby at once distributes the disease over the entire vascular system. In many of our experiments the inoculation was merely subcutaneous, and hence the bacteria must be diffused along different routes in order that the peculiar restriction of the disease processes may take place. Thus, in the limitation of the swine-plague bacteria to the pleura after subcutaneous inoculation over the lower part of the abdomen, or in the infiltration and suppuration of Peyer's patches after the subcutaneous injection of hog-cholera bacilli, the route of the bacteria is much more circuitous than in simple intravenous injection, where we may conceive of a complete suppression of the growth of the injected bacteria, excepting at the seat of the lesions. It is not our purpose to attempt an explanation of the phenomena brought out by the immunizing experiments. A complete explanation would presuppose a complete elucidation of the problem of immunity in all its bearings.

A further corollary of much importance may be deduced from these experiments. By increasing the resistance of the smaller experimental animals or by reducing the virulence of the inoculated bacteria we obtain a type of disease simulating that of larger, more resistant species of animals, such as swine. This is very well illustrated in the two diseases experimented upon.

1. By modifying the hog-cholera disease in rabbits so as to prolong it to twice or three times its usual period we obtain instead of the usual septicæmic type, as described on page 10, a true hog cholera as it manifests itself in swine. The lesions become localized in the digestive tract. The solitary and agminated follicles become infiltrated and converted into ulcers and the mucosa of the cæcum may become ulcerated in large patches, as in the cholera of swine. In some rabbits the disease may become localized in the lungs, as is now and then the case in swine.

2. By modifying swine plague in rabbits so as to prolong the disease from twenty hours to a week or more, a localization of the disease in the thoracic organs appears, which corresponds closely with the disease in swine. The bacteria appear to multiply first in the pleural cavity and then to invade the lung tissue secondarily, for the pulmonary lesions may be absent or else restricted to those dependent lobes on which the pleural exudate is most abundant.

These results make it intelligible how much the disease of hog cholera, for example, may vary in pigs in accordance with any variation in the virulence of hog-cholera bacilli and the relative immunity of

* Comptes rendus de la Société de Biologie, 1893, pp. 730, 762.

swine, and how difficult it is to decide upon the causation of any particular set of changes in the animal without having recourse to the bacteria involved. We may take it as settled that, in general, swine are not very susceptible to both hog cholera and swine plague. This is proved by the difficulty encountered in producing either disease artificially with pure cultures. The localization of the disease, as compared with the disease in rabbits, also shows this to be true. In other words, when epizootics of either disease appear among swine they are due largely to aggravating circumstances, and the removal of these is the key to the prevention of swine diseases.

Preventive inoculation, as it has been practiced on domestic animals, does not always insure absolute immunity. Since all immunity is relative and a matter of degree, the resistance of the animal vaccinated will depend upon conditions both internal and external. While vaccination may protect from an acute attack, it may lead to a slower, more chronic disease, not easily recognized, but equally if not more dangerous than the more acute disease, because the animal may become the source of infection for other animals. Such animals are also a loss to the owner, as they are not in a condition to thrive, and will succumb to the chronic affection sooner or later.

Interesting confirmation of these deductions from experimentation with the bacteria of hog cholera and swine plague comes from studies of a European swine disease, *rouget*, or swine erysipelas. This disease exists in nature in about five varieties, and some of these varieties are produced by the process of vaccination. Originally described as a rapidly fatal septicæmia in swine, it has been observed in recent years that it may also appear as an endocarditis. On the inner surface of the heart—usually the left ventricle—wart-like growths are found occupying the mitral valve and almost completely obstructing the flow of blood from auricle to ventricle. In these growths there is a considerable deposit having the character of a thrombus, and in this soft mass *rouget* bacilli vegetate in large numbers.

This *rouget* endocarditis has been observed both as a result of vaccination with Pasteur's vaccine and in the course of the natural disease. Hess and Guillebeau * have given some good illustrations of this type of the vaccination disease. Some of the pigs become ill after vaccination and never make a good recovery. In these after death or slaughter the infectious endocarditis is found.

The same form of heart affection was found by Bang † quite common in Denmark. The course of the affection as observed by veterinarians in that country was as follows:

When *rouget* appeared in a herd of swine it would usually cause more or less acute disease with a certain number of deaths. The

* Schweiz. Archiv f. Thierheilkunde, xxviii, 1886.

† Ueber Rothlauf-Endocarditis bei Schweinen. Deutsche Zeitschrift f. Thiermedizin, xviii (1891), p. 27.

remainder of the herd would make a good recovery. One or more months later some would die quite suddenly, the cause of death being infectious endocarditis as a result of the vegetation of rouget bacilli on the valves of the heart. Cases of heart disease were also observed which had not passed through any recognizable acute attack of rouget previously.

Recently C. O. Jensen* described in detail an infectious disease of swine in Denmark, known as urticaria (*Nesselfieber*), which is a modification of the same rouget disease of the continent. At about the same time Dr. Lorenz† described a disease as occurring in Germany which Jensen considers identical with urticaria. It occurs more especially in the warmer season of the year and very rarely ends fatally. At the onset of the disease the pigs become dull, crawl into their bedding, breathe more rapidly, and refuse all food. The temperature rises and may reach (42° C.) 107.6° F. Soon after the onset of these symptoms a peculiar eruption appears on the body, which consists of red, brown, blue, or blackish spots, rectangular in form and sharply outlined (hence the German name *Backsteinblattern*). The longer side of this rectangular reddened spot may be one half to one inch long, the shorter side about one-third less.

The disease disappears after a few days, but the spots may persist one or two weeks, after which a blackish scab peels off. Lorenz cultivated from one of these red spots a bacillus which closely resembles the bacillus of rouget, both in its biological and pathogenic properties. Rabbits which survived inoculation with rouget resisted successfully inoculation with these bacilli. Jensen's description closely agrees with that of Lorenz. The latter calls attention to the red spots as being not always rectangular, but also roundish or diamond shaped. Jensen in the same article also describes a disease in swine associated with necrosis and sloughing away of large pieces of the skin, sometimes one or more square feet in area. The microscopic examination of such sloughs revealed the presence of large masses of bacilli identical with those of rouget.

Jensen gives the following affections of swine as due to the same bacillus:

1. *Rouget blanc*.
2. Rouget as it is usually known.
3. Diffuse necrotic inflammation of the skin.
4. Urticaria.
5. Endocarditis verrucosa bacillosa.

The careful comparison of cultures from all of these affections, excepting No. 3, of which cultures were not at hand, revealed such slight variations as are common to other species of bacteria.

* Die Aetiologie des Nesselfiebers u. der diffusen Hautnekrose des Schweines. Deutsche Zeitschrift f. Thiermed, XVIII (1892), p. 278.

† Archiv. für wiss. u. prakt. Thierheilkunde, XVIII (1892), p. 39.

The form of inoculation disease characterized by the presence of pseudo-tuberculous lesions has certain counterparts in some inoculation diseases among lower animals which have been studied by various observers. In order to trace any possible relationship between the group of hog-cholera bacteria and those that have been described as the cause of experimental pseudo-tuberculosis in rabbits and guinea-pigs the literature of this subject has been examined.

Pseudo-tuberculosis in guinea-pigs was first produced by Malassez and Vingal* and reported in 1883 as "tuberculose zoogloëique." Cultures of the bacteria described as occurring in the tubercles were not made.

Soon after Eberth† described an eruption of submiliary tubercles on the serous membrane of the colon; on the omentum and in the spleen and liver of a rabbit. The tubercles consisted in the main of granulation cells. The bacteria present, according to the description given, resembled hog-cholera bacilli in form and staining. Cultures were not made, however.

In 1888 Charrin and Roger‡ described a pseudo-tuberculous affection produced in rabbits and guinea-pigs by a motile bacillus from 1 to 2 μ long, which multiplies well in ordinary culture media. The bacillus was originally obtained from a guinea-pig which died spontaneously. A subcutaneous inoculation leads to slow emaciation, and death on the thirteenth day. Besides the local swelling, the nearest lymph glands become enlarged, and numerous tubercles are found in spleen and liver. In the lungs they are scarce.

Dor§ found what appears to be the same disease independently of Charrin and Roger. The bacillus he isolated contains, in potato cultures, terminal spores. The disease could not be reproduced with cultures, although the pathological products readily produced it. This leaves the impression that the bacillus isolated was not the one causing the tubercles. Grancher and Ledoux,|| in 1888, obtained from the soil a bacillus which produced lesions similar to those described by former observers as pseudo-tuberculosis. This organism is described as a motile bacillus 1 to 2 μ long, which may, however, assume the form of a very short rod or an ovoid micrococcus. The optimum temperature of the culture is 20° C. This is perhaps the only point in which this bacillus differs appreciably from the colon or hog-cholera group. It should be stated, however, that important cultural characters, among them the action on milk, are omitted. In the tissues the organism grows in the form of long interlacing chains, of which great masses may appear in certain types of the inoculation disease as the so-called

*Arch. de physiol. normale et pathol., 1883.

†Arch. f. pathol. Anatomie, CIV (1886), p. 488.

‡Comptes Rendus, 1888-i, p. 868.

§Loc. cit., p. 1027.

||Recherches sur la tuberculose zoogloëique. Archives de Méd. Expér., I (1889).

zoöglæa of Malassez and Vignal. In some types of the disease produced by inoculation the prompt appearance of tubercles may suppress the formation of the zoöglæa. The bacilli may then appear in the tubercles, either isolated or in small masses.

A. Pfeiffer* published in 1889 a short monograph on a form of pseudo-tuberculosis produced by a bacillus originally derived from a glandered horse. Portions of a lung nodule and of a diseased gland were placed under the skin of guinea-pigs with the result that pseudo-tuberculosis and not glanders destroyed the inoculated animals in eight to nine days.

The isolated bacillus differs according to Pfeiffer's detailed careful description only in a few particulars from the hog-cholera group. It is non-motile† and grows preferably in chains. The markings of the surface colony on gelatin plates are also somewhat different from those observed in the hog-cholera and the colon group. Nevertheless the characters as described place this bacillus easily within the hog-cholera group and separate it from the colon group by the absence of any coagulative or other changes in milk.

The lesions observed by Pfeiffer varied somewhat. In the earliest inoculations into guinea-pigs, there was marked infiltration of the inguinal glands with dissemination of nodules in the surrounding connective tissue, in omentum, spleen, and liver. In subsequent inoculations, with death in nine days, the mesenteric glands were greatly enlarged, miliary and submiliary nodules were present in large numbers in spleen and liver. In the spleen there was also a caseous tubercle as large as a pea. The inguinal glands as before.

In still later inoculations, the guinea-pigs died in twenty to twenty-five days. The lesions were still more extensive. To those already described there were added a serous fluid in abdomen, a cheesy deposit on pleura, with a sanguinolent fluid in the pleural cavity, and numerous necrotic foci in the lungs.

By feeding cultures to mice, rabbits, and guinea-pigs, the disease is produced with equal success. The pseudo-tuberculous infiltration is restricted to the lymphatic apparatus of the intestines and to the liver. Among the animals found susceptible are guinea-pigs, wild and tame rabbits, gray and white house mice.

Zagari‡ in 1890, described a form of pseudo-tuberculosis encountered as a spontaneous or natural infection in four guinea-pigs. The isolated bacillus appears in cultures as a non-motile form in long chains, easily broken up, and in shorter oval elements. Its cultural characters so far as given do not differ materially from those of the hog-cholera group. The bacilli appear in masses in the center of the tubercles which con-

* Ueber die bacilläre Pseudo-tuberculose bei Nagethieren. Leipzig, 1889.

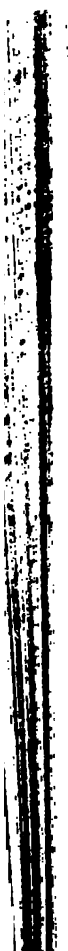
† See Bacillus η , page 16.

‡ Ueber die sogenannte Tuberculosis "zoögleica" oder Pseudo-tuberculose. Fortschritte der Medicin. 1890, pp. 569, 629.

sist of lymphoid elements chiefly. The center of the tubercles may undergo necrosis and caseation. After subcutaneous inoculation of culture fluid a firm infiltration appears at the seat of inoculation which may reach the size of a walnut and subsequently ulcerate. Death ensues in twelve to sixteen days. The neighboring lymph glands are found enlarged. In spleen, liver, and lungs many yellowish, isolated tubercles from the size of a hemp seed to that of a pea are found.

From this brief summary of the bacteriological side of the pseudo-tuberculosis literature we see certain general resemblances between the bacilli found and those belonging to the hog-cholera group. The differences observed are by no means vital. We do not wish to argue for or against any close relationship, however, until more data are at hand. The production of tubercles with attenuated hog-cholera bacteria or with virulent bacteria in partly immune animals is of sufficient importance to warrant the above summary. Further study of spontaneous pseudo-tuberculosis might perhaps lead to a better understanding of the origin of the hog-cholera group of bacteria.

The foregoing investigations throw much light upon the possible variations of all infectious diseases, both human and animal. We need but recall here the great variety of lesions produced by the ordinary septic and pyogenic bacteria of man, the staphylococci and the streptococci. Furthermore, most specific infectious diseases show variations in type, variations in the localization of the most distinctive pathological alterations. Some obscure forms of disease still needing elucidation may perhaps be recognized in the future as modifications of such as are already understood. As illustrations may be cited the recent discussions as to whether certain obscure diseases of man are of leprous origin or not, or whether scarlatina is a simple form of streptococcus infection. The outcome of our work emphasizes the importance of renewed continuous etiological studies. In infectious animal diseases this is of the utmost importance, for the unrecognized existence of some form of an infectious disease favors its unchecked dissemination. The confusion which has prevailed on the subject of infectious swine diseases must be attributed largely to the many possible variations in the symptoms and lesions as determined by post-mortem examinations. Such variations are due on the one hand to the condition of the animal as regards individual resistance, age, breed, the state of the internal organs, the amount of fat, etc., on the other to the virulence of the specific bacteria. The only final test of the nature of the disease is the character of the bacteria responsible for it.



CAN THE BACILLUS OF HOG CHOLERA BE INCREASED IN VIRULENCE BY
PASSING IT THROUGH A SERIES OF RABBITS?

By VERANUS A. MOORE.

In 1890 Selander* reported the results of certain experiments with the bacillus of *Scinpest* (Danish hog cholera), in which he showed that its virulence could be rapidly accelerated by passing it through a series of rabbits or pigeons. He furthermore affirmed that the germ was identical with the bacillus of American hog cholera. This most remarkable result, which was quite contrary to the conclusions which had been reached from the work in this laboratory, gave rise to the presumption that his culture had inadvertently become contaminated with the swine-plague or some other organism more virulent than the bacillus with which he was working, and consequently the question was temporarily dismissed.

In 1892 the results of Selander were confirmed by Metchnikoff† in an article on certain experiments concerning the immunizing properties of the products of hog-cholera bacteria. As no extended experiments had been made in this laboratory in precisely the line followed by Selander, it became necessary after Metchnikoff's publication to determine more positively whether or not the bacillus of hog cholera was susceptible to such rapid changes in its virulence. That hog-cholera bacteria of different degrees of virulence exist in nature had already been demonstrated by inoculation experiments with the bacilli isolated from different outbreaks of that disease. The tenacity with which these bacteria retained the virulence which they possessed at the time of their isolation, when cultivated under ordinary conditions or by passing them through experimental animals, had also been observed. Many efforts had been made to change the virulence of these bacteria, but invariably the results showed that it could not be quickly done by any of the methods employed.‡ The double assurance, therefore,

* Annales de l'Institut Pasteur, IV (1890,) p. 543.

† *Ibid.*, VI (1892), p. 289.

‡ See Reports of the Bureau of Animal Industry since 1885.

from European investigators that the virulence of the American hog-cholera bacillus could be rapidly increased by passing it through a series of rabbits was somewhat startling. Either to verify their results which appeared at the time to be of much significance, or to acquire additional evidence to support the theory that the virulence of this bacillus is not subject to such artificial changes, an experiment on rabbits was made.

After this experiment was completed it was found that the germ with which Metchnikoff had worked was the bacillus of swine plague* and not of hog cholera, as stated in his article. As he confirmed Selander's experiments, it was not unreasonable to suppose that Selander had made the same error. We have, however, no positive evidence of this, as a culture of his germ has not been studied, and the presumption of an error in the identification of the organism is necessarily based solely on the results he reported and on the statements of Metchnikoff. As the bacillus of the disease in Denmark was described by Selander,† and according to his description it closely resembles the bacillus of hog cholera in form, motility, growth in gelatin, and appearance in animal tissues, it seems unjust to affirm, on the evidence cited, that he had made a mistake in the identification of a germ which he himself had described. On this account his experiment is given that his results may be compared with those obtained in a similar experiment with the bacillus of American hog cholera.

His experiment was made for the purpose of increasing the virulence of the bacteria of *Svinpest* (hog cholera) by passing them through a series of rabbits and pigeons. The germ which he used had been preserved by means of subcultures in gelatin for about two years. It was originally obtained by Selander from an organ of a pig. After this long cultivation it required 1 cc. of a bouillon culture to destroy a rabbit in three days; it would not kill pigeons. With this virus Selander conducted the following experiments:

The spleen of a rabbit which perished in three days from a subcutaneous inoculation with a pure culture was made into an emulsion and a second rabbit inoculated subcutaneously with 1.5 cc. of this emulsion;‡ a third rabbit was inoculated with a similar quantity of an emulsion made with the spleen of the second rabbit, and a fourth from that of the third. The fourth rabbit died in fourteen hours. Three pigeons were inoculated subcutaneously with 0.1, 0.25 and 0.5 cc., respectively, of the emulsion of the spleen of the fourth rabbit. They perished in fourteen, five, and seven days, respectively. With the blood of the first pigeon, which had been in the incubator for several hours in order that the bacteria could multiply, a fourth pigeon was inoculated (five drops of the blood mixed in a little bouillon was injected); it

* At Dr. Smith's request Metchnikoff very kindly sent him a culture of the bacillus with which he had worked. It was found to be identical with the swine-plague germ. For a description of this organism see footnote, p. 60, in this publication.

†Centralblatt für Bakteriologie und Parasitenkunde. Bd. III (1888), p. 362.

‡He does not state how much or what liquid was used to make the emulsion, and consequently the strength of the dose can not be estimated.

perished in thirty-six hours. He continued the passage from pigeon to pigeon until 148 pigeons had been inoculated. The fifth pigeon perished in less than twelve hours. In subsequent cases death occurred in from eighteen to thirty-six hours. Later the irregularities became less and less, and the virulence of the germ fixed, so that a pigeon inoculated at 6 in the evening with from 0.05 to 0.2 cc. of the defibrinated blood of the preceding one would be found dead on the following morning. A very few of the pigeons resisted for a few days. In these, few bacteria were found in the blood, but each exhibited pericarditis with a fibrinous exudate rich in bacteria. The bacteria which were exalted in their virulence for pigeons were also rapidly fatal to rabbits. A subcutaneous inoculation with 0.01 to 0.25 cc. destroyed rabbits in from twelve to fifteen hours, and a rabbit inoculated in the ear vein with 0.05 cc. of virulent blood perished in five hours. The blood from the pigeons was also rapidly fatal to swine. A pig nine weeks old received 0.5 cc. of the blood from pigeon No. 37 in the ear vein at 2 o'clock on the morning of April 3. It was found dead the following day.

It was my purpose to repeat Selander's experiment in every detail in order that a more accurate comparison of the results could be made. A few omissions in the details of his work, however, rendered it impossible to determine certain minor points in his process. The history of the bacillus which I used and the method that was followed in this experiment are appended.

The bacillus was obtained in pure culture from the spleen of a pig which died of hog cholera in La Salle County, Ill., in the fall of 1891. It had been preserved by means of subcultures on agar for about eight months when this experiment was begun. It had not lost its virulence to any appreciable degree. Rabbits inoculated subcutaneously with 0.1 cc. of a fresh bouillon culture would die in from five to eight days. It should be stated that hog-cholera bacteria have rarely been found in the investigations of this laboratory that were sufficiently virulent to destroy rabbits in less than three days when they were inoculated subcutaneously with not more than 0.1 cc. of a fresh bouillon culture. In the preparation of the emulsion from the spleen of the rabbits the following order was observed:

The rabbits usually died during the night. They were examined sometime between 9 and 11 o'clock on the following morning. The spleen was removed very carefully to prevent contamination from without. It was cut into small pieces with sterile scissors and then ground up in a sterilized mortar with 10 cc. of sterile bouillon. Of this emulsion 0.5 cc. was used for each inoculation. Gelatin roll cultures were made from the emulsion in several instances. These developed as many colonies as would usually appear in similar rolls made from fresh (twenty-four-hour) bouillon cultures. The appended table contains all necessary information concerning these inoculations:

Series of inoculations in rabbits with hog-cholera bacteria.

Rabbit number—	Weight of rabbit.	Date of inoculation.	Rabbit inoculated subcutaneously with—	Date of death.	Time rabbit lived after inoculation.	Remarks.
	<i>Grams.</i>				<i>Days.</i>	
1	1,482	May 23, 1892	0.25 cc. bouillon culture, hog-cholera bacteria.	May 28	5	Usual hog-cholera lesions.
2	1,482	May 28, 1892	0.5 cc. emulsion spleen, rabbit 1...	June 2	4	Echymoses beneath pleura and pericardium.
3	1,368	June 2, 1892	0.5 cc. emulsion spleen, rabbit 2...	June 7	5	Usual hog-cholera lesions.
4	1,216	June 7, 1892	0.5 cc. emulsion spleen, rabbit 3...	June 11	4	Lower colon and duodenum hemorrhagic.
5	1,596	June 11, 1892	0.5 cc. emulsion spleen, rabbit 4...	June 18	8	Usual hog-cholera lesions.
6	1,767	June 18, 1892	0.5 cc. emulsion spleen, rabbit 5...	June 21	3	Very many coccidia in liver.
7	1,140	June 21, 1892	0.5 cc. emulsion spleen, rabbit 6...	June 29	8	Very severe local reaction; punctiform hemorrhages in peritoneum.
8	1,596	June 29, 1892	0.5 cc. emulsion spleen, rabbit 7...	July 5	6	Usual hog-cholera lesions.
9	1,672	July 5, 1892	0.5 cc. emulsion spleen, rabbit 8...	July 11	6	Do.
10	1,140	July 11, 1892	0.5 cc. emulsion spleen, rabbit 9...	July 15	4	Do.
11	1,425	July 15, 1892	0.5 cc. emulsion spleen, rabbit 10...	July 22	7	Do.
12	1,596	July 22, 1892	0.5 cc. emulsion spleen, rabbit 11...	July 27	5	Do.
13	2,280	July 27, 1892	0.5 cc. emulsion spleen, rabbit 12...	Aug. 1	5	Do.
14	1,710	Aug. 1, 1892	0.5 cc. emulsion spleen, rabbit 13...	Aug. 6	5	Do.
15	1,425	Aug. 6, 1892	0.5 cc. emulsion spleen, rabbit 14...	Aug. 12	6	Do.
16	1,425	Aug. 12, 1892	0.5 cc. emulsion spleen, rabbit 15...	Aug. 17	5	Do.
17	2,223	Aug. 17, 1892	0.5 cc. emulsion spleen, rabbit 16...	Aug. 24	7	Do.
18	1,824	Aug. 24, 1892	0.5 cc. emulsion spleen, rabbit 17...	Aug. 30	6	Spleen unusually small.
19	1,026	Aug. 30, 1892	0.5 cc. emulsion spleen, rabbit 18...	Sept. 3	4	Spleen apparently normal.
20	1,710	Sept. 3, 1892	0.5 cc. emulsion spleen, rabbit 19...	Sept. 9	6	Usual hog-cholera lesions.
21	1,824	Sept. 9, 1892	0.5 cc. emulsion spleen, rabbit 20...	Sept. 14	5	Do.
22	2,280	Sept. 14, 1892	0.5 cc. emulsion spleen, rabbit 21...	Sept. 19	5	Do.
23	1,710	Sept. 19, 1892	0.5 cc. emulsion spleen, rabbit 22...	Sept. 26	7	Do.
24	1,254	Sept. 26, 1892	0.5 cc. emulsion spleen, rabbit 23...	Oct. 1	5	Do.
25	1,311	Oct. 1, 1892	0.5 cc. emulsion spleen, rabbit 24...	Oct. 6	5	Do.
26	1,596	Oct. 6, 1892	0.5 cc. emulsion spleen, rabbit 25...	Oct. 11	5	Do.

The table shows that a series of inoculations with the hog-cholera bacillus, including 26 rabbits and extending over a period of more than four months time, had no effect whatever in increasing its virulence. In fact, the average time required for the inoculation to kill a rabbit in the first half of the experiment was a trifle shorter than that required with the last ten animals, which indicates a tendency toward attenuation rather than exaltation of the virus. The more rapid death of rabbit No. 6 is explained by the severe invasion of coccidia in the liver. The slight difference in the time required for the inoculation to produce death in the different rabbits can be accounted for on the ground of individual susceptibility or resistance.

Selander's germ was said not to be virulent enough to destroy pigeons, but that the emulsion of the spleen of the fourth rabbit would do so when inoculated in very small quantities. The bacillus of hog cholera which I used in making the rabbit experiment would occasionally kill pigeons when 0.5 cc. of a bouillon culture was injected into the pectoral muscle. This would indicate that his germ was less destruc-

tive to pigeons than the one I employed. However, a series of inoculations in pigeons was attempted in order to complete the comparison and to test the effect on the virulence of the hog-cholera bacillus by passing it through a series of pigeons. That a slight degree of increase in the virulence of the bacillus produced in this way might be detected, a few pigeons were inoculated with a pure culture of the bacillus made directly from the culture from which the first rabbit in the series was inoculated. Pigeons were then inoculated with certain quantities of the emulsion from the spleen of different rabbits in the series, to determine whether the bacillus had become more virulent for pigeons than it was at the beginning of the rabbit experiment. The result of the preliminary inoculations into pigeons is given in the following table:

Inoculation of pigeons with hog-cholera bacteria.

Pigeon number—	Date of inoculation.	Method of inoculation.	Virus used.	Results.
1	May 25, 1892	In pectoral muscle..	0.1 cc. bouillon culture..	Sick; recovered.
2	..do ..	..do ..	0.25 cc. bouillon culture..	Died in 22 hours.
3	..do ..	..do ..	0.5 cc. bouillon culture..	Died in 36 hours.
4	May 27, 1892	Beneath the skin....	0.25 cc. bouillon culture..	Sick; recovered.
5	..do ..	..do ..	0.5 cc. bouillon culture..	Do.
6	June 11, 1892	..do ..	0.5 cc. emulsion spleen, rabbit No. 4.	Do.
7	..do ..	..do ..	0.25 cc. emulsion spleen, rabbit No. 4.	Remained alive; unthrifty.
8	..do ..	..do ..	0.1 cc. emulsion spleen, rabbit No. 4.	Do.
9	..do ..	In pectoral muscle..	0.25 cc. emulsion spleen, rabbit No. 4.	Do.
12	June 20, 1892	..do ..	0.5 cc. bouillon culture..	Died in 24 hours.
13	June 23, 1892	Beneath the skin....	0.5 cc. blood pigeon 12...	Remained well.
14	..do ..	..do ..	0.75 cc. blood pigeon 12...	Died in 4 days.

The uncertainty with which even a large quantity of the culture or emulsion of the spleen of the rabbits, or of the pectoral muscle of the pigeon would kill pigeons, rendered a consecutive series of inoculations impossible. After several efforts to obtain such a series, in which a large number of pigeons were used, the experiment was abandoned. Certain of the pigeons that died from the inoculation were placed in an incubator for from six to twenty-four hours that the hog-cholera bacteria might multiply before the emulsions were made from the pectoral muscle or heart blood, but no additional virulence was obtained. A series of inoculations into the pectoral muscle which was begun with the emulsion of the spleen from rabbit No. 15 gave promise of success, but after a few successful inoculations the virus became contaminated with *Bacillus fluorescens liquefaciens*.* The mixed culture was more virulent, but after isolating the bacteria by means of agar plates the hog-cholera bacillus failed to kill pigeons when 0.5 cc. of a bouillon

* The *B. fluorescens liquefaciens* was fatal to pigeons when 0.5 cc. of a fresh bouillon culture was injected into the pectoral muscle. This is the second time that I have found this species of bacteria possessed of pathogenic properties. It is very frequently isolated from diseased animal tissues, the secretions covering the mucous membranes and from various extraneous material.

culture was injected into the pectoral muscle, showing that its virulence had not been appreciably increased.

The results obtained in these series of inoculations are important in demonstrating the constancy of the virulence of the hog-cholera bacillus when treated in this manner. They fully verify the results of more fragmentary experiments heretofore made with this bacillus and show conclusively that the results obtained by Selander do not hold true for American hog-cholera bacteria.

In the preceding article it was shown that by substituting the words swine plague for hog cholera in Metchnikoff's work his results could be verified. In the same article (p. 67) it was found that the swine-plague bacteria obtained from the abscess in the abdominal cavity of rabbit No. 16 were attenuated, but that they were restored to their original virulence by passing them through a series of three rabbits.* In this case, however, the rabbits were inoculated with fresh cultures instead of emulsions from the spleen. This single experiment with virulent swine-plague bacteria, which had become temporarily attenuated by their long life in the abscess, is in harmony with Selander's results. The conditions are also comparable, as his bacillus was at one time virulent, but had become attenuated through long cultivation. It is a significant fact that while he carried on a long series of inoculations his bacillus reached a high degree of virulence in three passages, as the fourth rabbit died in fourteen hours. These results indicate that if we substitute swine plague for hog cholera and *Svinpest* in Selander's article his work also can be verified.

The final and most important conclusion to be drawn from the foregoing experiment is the reply to the question with which it was begun. To this there appears to be but one answer, namely, that the bacillus of hog cholera as encountered in swine can not be rapidly or even slowly increased in virulence by passing it through a series of rabbits.

* In the summer of 1893 a similar series of inoculations were made with the bacillus of rabbit septicæmia, which was obtained from an outbreak of that disease. No appreciable increase in the virulence of the germ was obtained. This bacillus was very attenuated, producing extensive pleuritis and death in from 2 to 4 days after an intravenous inoculation of 0.4 cc. of a fresh bouillon culture. This indicates that even germs belonging to the swine-plague group of bacteria which appear in nature in an attenuated condition are not so susceptible to artificial changes in their virulence as those which appear in a virulent form and are subsequently attenuated.

WHAT BECOMES OF HOG-CHOLERA AND SWINE-PLAGUE BACTERIA INJECTED IN SMALL NUMBERS INTO THE SUBCUTANEOUS TISSUE OF PIGS?

By VERANUS A. MOORE.

In the investigation of swine diseases it became desirable to determine the extent to which hog-cholera and swine-plague bacteria would be disseminated through the body of pigs when a small quantity of a pure culture of these organisms was injected beneath the skin. It was likewise important to determine the time during which these bacteria would remain alive in the organs of a healthy animal which had been inoculated.

EXPERIMENT WITH HOG-CHOLERA BACTERIA.

In the experiment with the hog-cholera bacillus four well-nourished pigs (Berkshire crosses) two and one-half months old and weighing from 45 to 60 pounds were selected. Two of them received subcutaneously, by means of a hypodermic syringe, on the inside of the right thigh, 1 cc. each, and the other two, 1.5 cc. each, of a bouillon culture of hog-cholera bacteria. The culture used was prepared by inoculating a tube of peptonized bouillon with hog-cholera bacteria and placing it in an incubator for two days, when it was removed and allowed to stand in the laboratory at the room temperature for three days more before it was used. The growth was vigorous and the bacteria still motile. A culture that had grown for five days was employed because in former experiments it had been noticed that a culture increases in virulence up to a certain age.

The pigs were killed at different intervals, and a very careful examination was made of all the organs, excepting the brain. In order to determine approximately the number of bacteria present in the different tissues a gelatin roll culture was made from each. As a check upon the roll culture, a tube of peptonized bouillon was inoculated from the same organs. For the sake of comparison, care was taken to use as nearly as possible the same quantity of tissue for each culture; of the solid organs a piece about the size of a small bean was taken, and of the blood two large loops. The tissues were thoroughly crushed and

broken by means of sterilized forceps. The tissues from which cultures were made from each animal were: the place of inoculation, blood from the heart, lungs, spleen, liver, kidney, lymphatic gland at the smaller curvature of the stomach, and the bronchial gland. Stained cover-glass preparations from the blood and spleen showed no bacteria; those from the local lesions in the first three animals that were killed contained a large number of hog-cholera bacteria, but in those from the fourth no germs could be found. The result of these examinations, together with the history of the inoculations, are summarized in the subjoined table:

Table showing the distribution of hog-cholera bacteria in the organs.

Pig number—	Date of inoculation.	Culture injected subcutaneously.	Pig killed—	Days after the inoculation.	Hog-cholera bacteria in bouillon cultures from—	Number of colonies of hog-cholera bacteria in the gelatin rolls.	Other bacteria in bouillon cultures from—
77	Nov. 3, 1891	cc. 1	Nov. 5, 1891	2	Local lesion.....	1,000-2,000	Bronchial gland, blood and liver. ^a
80	do	1.5	Nov. 10, 1891	7	Local lesion..... Bronchial gland..... Stomach gland.....	1,000-2,000 20 50	Liver. ^a
78	do	1.5	Nov. 14, 1891	11	Local lesion..... Bronchial gland..... Stomach gland.....	1,000-2,000 No colonies. No colonies.	Bronchial gland.
79	do	1	Dec. 5, 1891	20	No hog-cholera bacteria.	No colonies....	Bronchial gland.

^a A pure culture of an anaërobic, spore-bearing bacillus.

It is of interest to note that the bacteria were not found beyond the place of injection two days after the inoculation, and that in eleven days they did not develop in the gelatin rolls, excepting in the one made from the local lesion. It will be observed, however, that the hog-cholera bacteria were disseminated through the body, for they were detected in certain of the lymphatic glands five and eleven days after they were injected into the subcutaneous tissue. In thirty days they had disappeared from these glands and from the place of inoculation.*

* In the summer of 1893 a somewhat similar experiment was made by Dr. Smith for another purpose, but the results obtained are of interest in this connection. June 5, pig No. 144 was inoculated subcutaneously in the left iliac region with 1 cc. of a bouillon culture of hog-cholera bacteria. A swelling about 6 cm. in diameter developed at the point of inoculation. In the center of this there was a firm indurated nodule about 2 cm. in diameter. The swelling subsided in a few days, but the induration remained as a firm nodule for several weeks. July 8, it was reinoculated on the right side with 1 cc. of a similar culture. The local induration which followed was more severe than after the first inoculation. August 10, the pig was again reinoculated with a similar quantity of the hog-cholera culture. This time a small nodule developed at the point of inoculation. The pig was killed September 12, thirty-three days after the last inoculation, and tubes of bouillon and agar were inoculated with pieces of the local induration caused by the last inoculation, and with pieces of the liver. These remained clear, and cover-glass preparations made from the local induration showed no bacteria.

It is an interesting fact that in no case hog-cholera bacteria were found in the blood, spleen, liver, or kidneys, where they are almost invariably detected when the animals perish from hog cholera contracted either by exposure to the disease or by inoculation. It is unfortunate that a few additional cases could not have been added between the third and the fourth animal so that the time of the disappearance of the germs could have been more exactly determined.*

These inoculations demonstrate the fact that when hog-cholera bacteria are injected in small numbers they are taken to different parts of the body and harbored for a considerable time in certain lymphatic glands as well as in the subcutaneous tissue at the place where they were injected, and that eventually they are destroyed. There is very little, if any evidence, that the bacteria multiplied to any great extent within the animal body. The swelling at the place of inoculation can not be attributed solely to this cause, as injections of sterilized cultures have frequently been found to produce severe local reaction.

The other bacteria obtained from the bronchial glands were ordinary aerobic saprophytic organisms; the same is true of the germ found in the blood of pig No. 77. The anaerobic spore-bearing bacillus obtained from the liver of pigs Nos. 77 and 80 probably belonged to the group of bacteria containing *Bacillus butyricus*. It grew only in the bottom of bouillon tubes and died out after the second subculture was made.

The animals were killed by a blow on the head. This may account for the presence of bacteria in the blood of pig No. 77, as this animal lived some minutes after the blow was administered, giving the blood a chance to carry bacteria from the injured parts. The examination showed no lesions due to the injection of the virus, excepting a local swelling,† and at no time did the pigs show any ill effect from the injection of the bacteria. The local reaction as shown by the post mortem was somewhat variable, owing to the difference in the time of death after the inoculation.

A rabbit was inoculated subcutaneously with 0.1 cc. of the bouillon

*The considerable number of colonies of hog-cholera bacteria that developed in the roll cultures made from the lymphatic glands after five days, and their absence in the gelatin rolls made from the glands after eleven days had elapsed, indicate that the destruction of the bacteria in the lymphatics was nearly completed in that time.

† In pig No. 77 there was a purulent infiltration and thickening of the subcutis extending over an area 5 by 3 cm. In pig No. 80 the subcutis was thickened, quite firm and apparently necrosed over an area 8 by 2 cm. In pig No. 78 there was a quite firm tumor about 6 by 2 cm. underneath the skin. The exterior layer of the tumor was of a pale, pinkish, translucent appearance, while the interior was firm and whitish, due to a dense infiltration of leucocytes. It was attached to the subjacent muscle by loose connective tissue. In pig No. 79 there was a scar at the point of injection beneath which was a layer of purulent substance about 2 mm. thick, and extending over an area about 5 cm. in diameter. Around this the connective tissue was slightly thickened.

culture from the bronchial gland of pig No. 80. It died of hog cholera on the fourth day.

EXPERIMENT WITH SWINE-PLAGUE BACTERIA.

The experiment with swine-plague bacteria was carried out in a manner similar to the one with hog cholera just described. A few differences in the details, however, should be mentioned. Two pigs were selected from the same herd as those taken for the previous experiment. They were inoculated subcutaneously in the right thigh with 1 cc. each, of a turbid suspension in bouillon of the surface growth from an agar culture of swine-plague bacteria one day old.* As the swine-plague bacillus grew very unsatisfactorily in gelatin the cultures from the various organs were made on the inclined surface of agar and in bouillon. In other respects the details were the same as those already described in the experiment with hog-cholera bacteria. A summary of the inoculations and the result of the bacteriological examination of the various organs is given in the subjoined table:

Table showing the distribution of the swine-plague bacteria in the tissues.

Pig number—	Date of inoculation.	Bacteria injected subcutaneously.	Pig killed—	Days after inoculation.	Swine-plague bacteria in cultures from.	Colonies of swine plague on surface of agar.	Other bacteria in cultures from.
85	Nov. 14, 1891	1 cc. suspension agar cultures.	Nov. 16	2	Local lesion only.	So numerous as to be confluent.	Kidney. Bronchial glands and lung.
81	do.....	do.....	Nov. 20	6	do.....	do.....	Bronchial gland and liver. ¹

¹ Anaërobic spore-bearing bacillus.

From this experiment it is evident that the swine-plague bacteria were either not disseminated through the body, as in case of the hog-cholera bacilli, or that being taken up they were destroyed more rapidly than were the hog-cholera bacteria.

There were no disturbances produced by the inoculations, and the post-mortem examinations revealed no lesions that were produced by the injections, excepting the local reaction. This varied somewhat; in pig No. 85 there was a thickening of the subcutaneous tissue about the point of injection extending over an area 4 cm. in diameter; the subjacent muscle was roughened; considerable blood extravasation in the thigh muscle. In pig No. 81 there was a small (1.5 cm. in diameter) tumor beneath the skin at the place of inoculation consisting of a soft, grayish nucleus surrounded by a quite firm connective tissue wall.

From the cultures and cover-glass preparations it was impossible to determine whether there was any difference in the number of bacteria

*It should be noted that the turbid suspension from the agar cultures of the swine-plague bacteria injected was equivalent to a much larger quantity of a simple bouillon culture so far as the number of bacteria is concerned.

in the local lesion of the two animals produced by the injection of the bacteria. The tubes of agar inoculated developed confluent growths, and in stained cover-glass preparations no bacteria could be detected in either case. It is presumable that there was at most only a slight multiplication of the bacteria in the subcutaneous tissue. This is indicated by the somewhat diffuse lesion in the pig killed in two days and the formation of a circumscribed tumor at the seat of inoculation in the animal that was allowed to live six days.

The identity of the bacillus obtained from the local lesion of pig No. 81 was established by inoculating a rabbit with a very small quantity of the culture. It was found dead on the following morning and its organs contained innumerable swine-plague bacteria. The spore-bearing bacillus found in the bouillon culture from the liver of pig No. 81 was apparently identical with those found in cultures from the livers of pigs Nos. 77 and 80.

It is instructive to note that in 5 of the 6 pigs used in these experiments the bronchial gland was found to be infected with various species of bacteria. This fact is valuable as it demonstrates that bacteria may be carried through the lungs into the corresponding lymphatic glands.

From these experiments the following conclusions appear to be warranted concerning the fate of these bacteria when injected subcutaneously in small numbers.

1. Both hog-cholera and swine-plague bacteria will remain alive in the subcutaneous tissue for several days after their injection.

2. The hog-cholera bacteria are taken up from the point of injection and distributed, to a certain extent, through the body. They are harbored for a limited period of time in certain lymphatic glands where they may be detected. They are not found in the other organs of the body.

3. The swine-plague bacteria are not found beyond the tissues immediately surrounding the point of their injection.

4. Subcutaneous injection of small doses of either hog-cholera or swine-plague bacteria of ordinary virulence have little, if any, pathogenic effect.



PRACTICAL BEARING OF THE PRECEDING INVESTIGATIONS.

By THEOBALD SMITH.

The experience of the past fifteen years has amply shown that all facts concerning the nature of important disease germs, however insignificant they may appear by themselves, should be worked out and recorded. Slight variations or modifications of such potent organisms may express themselves in the shape of extensive epidemics and epizootics, for it seems to require but a slight elevation in the virulence of any pathogenic organism to greatly extend its injurious operations. The careful study of the hog-cholera group of bacteria is thus a matter of necessity. Thus far we have found a well-defined bacillus associated with outbreaks of hog cholera in a considerable number of localities, both in the East and the West. The relation of this bacillus to the disease is unquestioned. Furthermore, this bacillus occurs under a number of varieties, whose chief distinguishing character lies in the varying degree of pathogenic activity. Some are more, others less virulent, and the type of disease produced in swine is correspondingly varied. The outbreak from which a few cases are reported in full on page 27, and from which a well-defined variety was isolated, differs in important particulars from other types of uncomplicated hog cholera in the greater duration of the disease and the peculiar diphtheritic character of the inflammation of the intestines. The confusion existing even to-day in the minds of many authorities on the subject of swine diseases, expressing itself in the multitudinous names which have been given to them, evidently rests in part on the different types which hog cholera assumes as a consequence of the pathogenic variability of the bacillus.*

Besides those varieties of this bacillus actually encountered in swine diseases there are other more or less closely related varieties of this species or group of species which have been found in connection with disease among other domestic animals.

In Bulletin No. 3 I described a bacillus from the vagina of a mare after abortion, which certainly is a hog-cholera bacillus. In Europe, Gärtner found a bacillus in the organs of a sick cow, the meat of which

* In the bulletin on Swine plague (1891) a study of the varieties of the swine-plague bacillus will be found.

caused a widespread epidemic of gastro-intestinal disease in man. In the foregoing pages I have recorded facts which show that this bacillus is hardly more than a variety of the hog-cholera bacillus. The same may be said of the mouse-typhus bacillus of Loeffler, which the discoverer has recommended and used in the destruction of field mice and other pests.* In the observations given in the preceding pages this organism is shown to possess pathogenic properties of a high degree, but differing somewhat from those possessed by the true hog-cholera bacillus.

Both these organisms were found in Germany, yet there is no positive evidence that hog cholera exists there. It is true that neither organism is completely identical with the virulent hog-cholera bacillus as found in this country, yet they approach quite closely the less pathogenic varieties. This leads us to the broad question whether the different methods of rearing and feeding swine have led in the one country to a repression of such diseases, and in the other to an extension of them by reducing the resistance of the digestive organs of swine. The cultivation of the hog-cholera bacillus by the continuous existence of the disease may have finally led with us to races of maximum virulence.

Intimately associated with the problem of variations in this group is the one dealing with the possible extension of hog cholera to other domestic animals. This must be constantly kept in view, and attention has already been called to this phase of the hog-cholera problem in Bulletin No. 3. Thus far members of this group have been found in a cow, in mice, and in a mare after abortion. Even if the hog-cholera bacillus may not at present produce epizootics in other animals, the possibility is open that it may produce various disturbances in isolated cases, that it may act with other disease germs, and, finally, that it may slowly adapt itself to other species.

This adaptation must be a slow process, for the foregoing investigations show how tenacious the characters of the hog-cholera bacillus are and how difficult it is to modify its virulence, either by methods of cultivation or passage through animals. This fact, which has been brought out in various ways in former investigations, has been confirmed by the inoculation experiments reported by Dr. Moore on page 100. This species is, on the whole, very stable, and its very stability is responsible for its dangerous properties by putting obstacles in the way of preventive inoculation, disinfection, and the recovery of diseased animals.

In carrying on vaccination experiments on the smaller experimental animals we were guided by the fact that the problem of immunity is to-day the foremost one in the more abstruse study of infectious diseases, and that its ultimate solution will furnish efficient practical ideas concerning those causes which predispose animals to infection. The study of any one infectious disease will not lead us very far. A num-

* Annual Report of the Secretary of Agriculture for 1893.

ber of different maladies must be thoroughly exploited. For us the immediate task appears to be the investigation of the problem in connection with those animal diseases which are of the greatest economic importance and about which we had gathered together much information. In other countries the same problems have been attacked in connection with other diseases, and by mutual coöperation much advantage has accrued. In the experiments reported in these pages some important facts have been disclosed. We have learned that swine, as a rule, are not very susceptible to either disease. This is proven by the difficulty of producing disease either by feeding cultures or by injecting them under the skin. It is also shown by the nature of the diseases as they manifest themselves in swine. They are always localized in one or more organs, while in the very susceptible small animals both diseases appear as generalized septicæmic diseases of a speedily fatal character and are produced by inoculation with exceedingly minute doses. If swine therefore already possess a fair degree of immunity against these diseases we must look for accessory causes to account for the extensive mortality. Those conditions which favor an unhealthy condition such as monotonous, badly chosen food rations and animal parasites, especially lung worms and ascarides, have already been discussed in the bulletin on swine plague, as possible agents in breaking down those protective barriers to disease which in the swine diseases consist mainly in perfect digestion and healthy lungs. Swine should receive at least some of the attention and care that is given to other domestic animals, and sanitary laws can not be set aside without inviting disease germs to enter the system. It is taken for granted that proper precautions are to be taken at all times to prevent the introduction of sick or exposed animals into a herd, but there may be regions where the surroundings, the soil, and the water courses are being so continually infected that the disease germs may be presumed to be present at all times, and where the only safeguards against infection will be a proper amount of attention to the general health of the animals and to the removal of those conditions which are likely to impair it.

How important a part the food plays in predisposing animals to hog cholera and swine plague has not thus far been studied. Certain it is that such one-sided food as corn and water can not be recommended. It has been shown that when rats are fed on a flesh diet they are more likely to resist anthrax after inoculation than when fed on bread.* When those fed on bread also received salt, increased resistance was likewise observed. A reduction in the necessary quantity of proteid food with swine may perhaps be responsible for more injury than appears on the surface. Errors in feeding are not likely to limit their injurious activity to one disease alone but may increase susceptibility to disease in various directions. Improper food besides reducing the general resistance of the body cells to bacterial invasion may lead to

*Kurt Müller: Der Milzbrand der Ratten. Fortschritte der Medicin, 1893, v. 322.

a weakening of certain important organs such as the stomach. It has been frequently shown how important normal digestion is for the prompt destruction of bacteria in the food. A catarrhal condition inducing a less acid reaction of the mucous membrane may permit hog-cholera bacteria to pass through this organ alive and once in the small intestine they will invariably set up disease.

Our experiments have furthermore shown that the different degrees of susceptibility may produce quite a variation in the character of the disease, and that when a certain degree of immunity has been produced in rabbits it would be impossible to foretell what form the inoculation disease would assume. It might become localized in the intestines or the lungs, or even in the brain. Swine plague might appear as a peritonitis or a pleuritis with or without pneumonia, or in the form of one or more abscesses. This interesting fact is at present of most service to the investigator, because he will be better able to identify obscure diseases. It is needless to insist on the importance of this knowledge. The presence of mild, chronic hog cholera or swine plague in a herd may be fully as dangerous as the more acute disease, for mild disease is frequently caused by highly virulent bacteria. This has been fully brought out in the foregoing pages. Rabbits which, through vaccination, have lived many months after inoculation have continued to carry disease germs in their body virulent enough to kill unvaccinated rabbits in twenty hours.

Another fact of considerable importance is the relative character of the immunity produced by vaccination. An animal which before preventive inoculation possessed a high degree of susceptibility may after treatment no longer contract an acute rapidly fatal disease but one of a more chronic character, which dragging itself along for months and rendering the animal worthless may form the starting point of subsequent outbreaks among newly introduced or younger animals. This state of affairs has been noticed in Europe after vaccination against rouget, or swine erysipelas, a disease of swine thus far not found in this country.* While it is not of sufficient importance to militate against the use of successful vaccines, it should nevertheless not be lost sight of in a final estimate of the value of vaccination methods as a whole. Our observations on hog cholera lead me to believe that even if a fairly successful and cheap method of vaccination against hog cholera could be devised the result would be that a number of animals would contract a chronic type of the disease after infection, and these would have all the objectionable features of worthless animals scattering infection about for months.

In all efforts directed towards the production of a certain refractory state of the animal body towards certain disease germs, in other words, in all attempts at preventive inoculation, we must bear in mind that the effort expended is in direct proportion to the gravity of the disease

* See p. 91.

to be fought. This is very well illustrated in the experiments on rabbits and guinea-pigs. Only with great difficulty are these animals made refractory to inoculation with hog-cholera bacilli, while it is comparatively easy to induce a high degree of immunity towards swine-plague bacteria. In all experiments with living cultures or the products of cultures there is a retardation of growth of the vaccinated animal and even a loss of weight, which is the more pronounced the more thorough the preventive treatment. The most successful processes are also the most trying to the animal system. The apparently entirely harmless method of injecting the blood serum of immunized animals suffers from two disadvantages—the immunity is said to be transient unless the treatment is followed by an injection of living cultures, and the difficulties of obtaining the blood serum are considerable. In all methods of preventive inoculation, we must reckon with the cost, which should include the loss in weight and thriftiness sustained by the animals. It is safe to assume that any method which claims to produce immunity towards an infectious disease of a serious character with but little expense or injury of any kind should be looked upon with grave suspicion, for the energy required to bring the animal into the refractory state must on general principles balance or overcome the energy exerted by the disease germs on the unprotected animal organism.

That serious diseases of a slowly progressive character can not be cured or prevented by simple means has been amply demonstrated during the past few years by the history of tuberculin. At first supposed to act as a remarkably rapid cure for human tuberculosis, it is now considered of service only in the earliest stages of this disease. Even here its efficiency is brought out only by prolonged use in minute doses and combined with climatic treatment. It is thus shown that the energy expended in curing early cases is certainly very great, and when applied to animal life wholly out of proportion to the value of the animal, even if a cure could be effected. The same principle is applicable to preventive inoculation, with this difference, that it is very much easier to prevent disease than to cure it. The rapidly fatal diseases known as blood diseases or septicæmias seem to be more easily amenable to preventive inoculation. But even as to these (anthrax, rouget), opinions among authorities are divided, and it has been difficult to obtain any trustworthy data. It has already been stated that a chronic, eventually fatal, form of rouget may appear as a result of the vaccination or as a result of infection after vaccination. Hence, all cases of death among vaccinated animals should be carefully studied before any trustworthy knowledge of the effect of vaccines can be obtained.

Bringing all the facts brought out by the swine investigations together, we would suggest that more attention be paid to the collateral causes which contribute to fatality among swine. These collateral causes necessarily change with the climate, the food, and the manner of keeping such animals, and can be investigated only when the diseases pre-

vail. More attention should be paid to the effect of food, both in predisposing to hog cholera and swine plague and in producing diseases of the digestive organs which simulate hog cholera, but which are probably quite easily prevented. A thorough study should also be made of lung worms and ascarides. If these difficulties can be removed or mitigated, and if the diseases due directly to improper feeding be eliminated by more careful attention to fundamental principles, it is more than probable that the infectious swine diseases will largely disappear. This prediction is based on the fact, experimentally determined and already referred to, that swine naturally possess more or less immunity towards both hog-cholera and swine-plague bacteria, and that with vigorous digestion and sound lungs they may be able to resist the infection which can reach them in decently kept surroundings. We do not intend to deny the possibility that now and then highly virulent races of pathogenic bacteria appear, which are reported to sweep everything before them. These we have still to find. In the field our usual experience has been to find obscure diseases not definitely traceable to any disease germ, or else very chronic cases of hog cholera and swine plague. I would therefore urgently recommend a more extensive study of swine diseases in the field, which should include in its scope all causes of disease. Only by such investigations can we hope to determine the various agencies actually at work in different sections of our country in destroying swine, and to estimate more accurately the losses due to pure infection, to animal parasites, and to improper feeding.

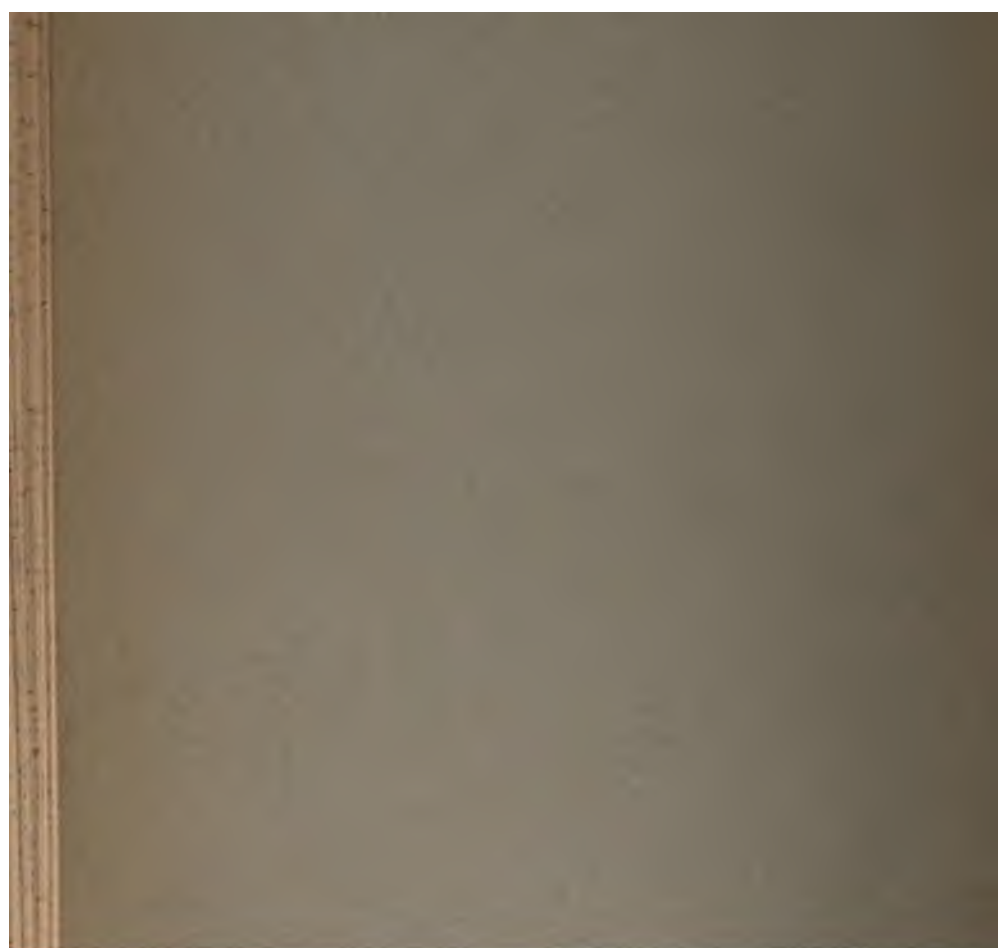
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U. S. DEPARTMENT OF AGRICULTURE.

BUREAU OF ANIMAL INDUSTRY.

BULLETIN No. 7.

INVESTIGATIONS

CONCERNING

BOVINE TUBERCULOSIS,

WITH

SPECIAL REFERENCE TO DIAGNOSIS AND PREVENTION.

CONDUCTED UNDER THE DIRECTION OF DR. D. E. SALMON,
CHIEF OF THE BUREAU OF ANIMAL INDUSTRY.

PUBLISHED BY AUTHORITY OF THE SECRETARY OF AGRICULTURE.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.

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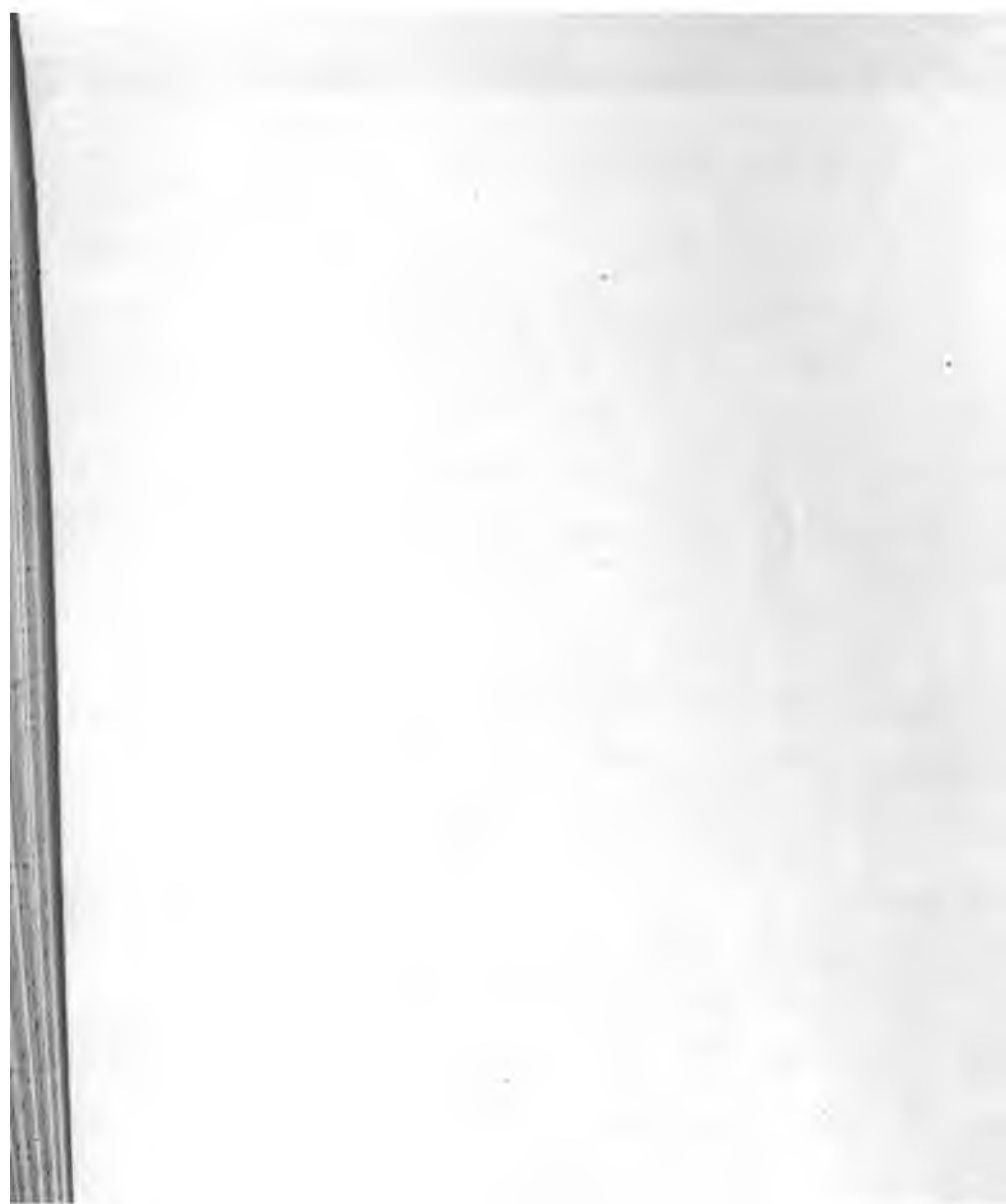
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LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., September 10, 1894.

SIR: I have the honor to transmit herewith a report submitted by Dr. Theobald Smith covering investigations made by himself, and by Drs. F. L. Kilborne and E. C. Schroeder under his direction, concerning the diagnosis and prevention of tuberculosis. I also transmit in this connection a report submitted to me by Dr. E. A. de Schweinitz on tuberculin and its use.

The researches which are the basis of these reports have been most carefully conducted, and the results are of great importance and interest on account of the accuracy of the observations and the light which they throw on the prevention and control of the most widespread and destructive plague that affects man and the domesticated animals.

The facts here presented do much to clear away the uncertainties which have confronted the practical sanitarian, and a continuation of such investigations, particularly if on a somewhat more extended scale, will soon enable us to clearly define the action necessary to protect the farmer from the ravages of the disease among his live stock and the consumer from the danger of taking into his system the infected products of tuberculous animals. In such studies it is the farmer who is most interested. Not only does he suffer the loss of his animals from the disease, but he is among the largest consumers of meat and milk, and, consequently, the health of himself and family is proportionately endangered. The farmer must also suffer the inconvenience and the greater part of the loss resulting from efforts for the eradication of the contagion. When these efforts are made by the State, it is a question whether this loss is not greater to the cattle owner, on account of the inconvenience of the season selected and the damaging effects of the publicity, than would follow from his individual action to accomplish equally beneficial results. The time has come, therefore, for our farmers to study this question carefully and decide, in the light of the facts published for their benefit, whether it would not be preferable to themselves free their herds from this plague, rather than wait the necessarily slow and often unpleasant action of the constituted authorities.

Very respectfully,

D. E. SALMON,
Chief Bureau of Animal Industry.

HON. J. STERLING MORTON,
Secretary of Agriculture.

LETTER OF SUBMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
Washington, D. C., July 21, 1894.

SIR: I have the honor to submit herewith some preliminary investigations and studies dealing with bovine tuberculosis both from an economic and a sanitary point of view. The former has been more or less neglected and the demands of public health allowed to overshadow it. It seems, however, that the difficulty is one which must be met primarily from the agricultural side and in the interests of agriculture. If this is successful the public health problem will have solved itself.

The articles contained in this bulletin are more or less technical inasmuch as they deal with fundamental problems. A chapter on the practical aspect of the whole subject has been added which embodies general suggestions on prevention. These will be readily understood by all interested in the practical bearing of bovine tuberculosis.

It remains for me to thank Dr. Cooper Curtice, formerly New York State cattle inspector, for the courtesy of permitting me to examine with him about 70 tuberculous animals slaughtered under the direction of the New York State Board of Health.

Very respectfully,

THEOBALD SMITH,
Chief of Division of Animal Pathology.

Dr. D. E. SALMON,
Chief of Bureau of Animal Industry.

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INVESTIGATIONS CONCERNING BOVINE TUBERCULOSIS.

CLINICAL AND PATHOLOGICAL NOTES ON A HERD OF 60 CATTLE TESTED WITH TUBERCULIN (SOLDIERS' HOME HERD.)

CLINICAL PART.

By F. L. KILBORNE, B. V. S., and E. C. SCHROEDER, M. D. V.

GENERAL HISTORY AND SANITARY CONDITION OF THE HERD.

In the year 1869 a small number of Jersey cattle, comprising 1 bull, 1 cow, and 3 heifers, were purchased at a fair in Baltimore, Md., and brought to the District of Columbia, where they were added to a herd of 25 cows of no particular breed, which belonged to the Soldiers' Home. The so-called common cows were sold as rapidly as their places could be filled by the progeny of the Jerseys and such of their own offspring as were sired by the Jersey bull.

A second Jersey bull was secured in the year 1874 and a third in the year 1886. The last bull died in the year 1889, after only two days of noticeable sickness. Previous to the introduction of the third bull the herd had increased to double the original number of cattle, and consisted exclusively of either pure Jerseys or cows in which the Jersey strain predominated. They were amply fertile and in good condition. A few deaths had occurred, some from parturient apoplexy and others from unknown causes, but the death rate never exceeded reasonable bounds.

An outbreak of abortion, which assumed a contagious form, occurred in the year 1882, and was not overcome until a considerable number of cows had been removed from the herd and their places filled with new stock. One bull, 6 cows, and 3 heifers of Holstein breed and 12 common cows were bought. The former came from Clifton, Va., and the latter mainly from Montgomery County, Md. The common cows were again sold as soon as their places could be taken by the offspring of the Holstein cattle and of the remaining Jerseys, and only the most vigorous and productive of the latter were retained. The Holstein cattle had the preference because the Jerseys seemed to have lost ~~their~~ former vitality.

The process of thinning out the common cows, and more gradually the Jerseys, continued without interruption, and the herd slowly increased in number until the time of the tuberculin test, when it consisted of 60 animals, the majority of which were more or less pure Holstein cattle and the balance Jerseys. The general condition of the herd was excellent, and with the exception of 2 or 3 cows it contained nothing which was suggestive of disease on superficial examination.

A second Holstein bull, from either New York or Pennsylvania, took the place of the first in the year 1887. The first was sold in good condition, but the second was sent in 1892 to the veterinary station of the Bureau of Animal Industry, and was found extensively tuberculous on post-mortem examination.

In addition to the several bulls spoken of, there were at different times several other bulls which were the progeny of and raised in the herd.

The stables in which the herd was kept are located in the grounds of the Soldiers' Home. Together with an unused horse stable, a dairy room, a number of box stalls, tool houses, storerooms, and open sheds, they form a rectangle which incloses a paved yard not less than 100 feet long and 60 feet wide, the long diameter of which extends north and south. All the buildings are entered through the inclosed yard.

The principal stable, which is the only structure more than one story high, is 75 feet long and 40 feet broad, and forms the greater portion of the eastern side of the rectangle. The upper story is used as a hay loft. The lower story, with the exception of a space 18 feet wide at the northern end, is occupied by three rows of fourteen stalls each, two facing each other, and separated by a passage 4 feet wide, and a third row with its rear turned towards the other two, from which it is separated by a space 4 to 5 feet wide.

Two smaller stables used for cattle form the southwestern angle of the rectangle. The smaller of the two is 25 feet square and contains two rows of six stalls, facing each other, with a passage 3 to 4 feet wide between. In the larger, which measures 40 by 30 feet, are two rows of ten stalls, facing each other and separated by a passage 4 to 5 feet wide. In the latter stable the cattle are fastened in stanchions, in the other two by means of chains.

All the buildings are of brick excepting the second story of the principal stable. The stalls are about 4 feet wide and have plank floors which rest upon a layer of cement. In the rear of each row of stalls is a covered drain with openings at regular intervals. At the head of each stall is a trough and hay rack.

The light and ventilation are good. In the largest stable, in which the ceiling is lowest, the latter is at least 8 feet high. This stable is ventilated by two air shafts. Light is obtained in all the stables through numerous glazed windows which can be opened in warm weather. The floors are dry and kept scrupulously clean.

The drainage from all the stables collects in a covered cesspool which is in the inclosed yard about 10 feet from the center of the main stable. This pool has one objectionable feature. It is 9 feet deep and the discharge pipe leading from it is only 3 feet beneath the surface, and hence the drainage from the stables to the depth of 6 feet stagnates constantly in this pool and frequently gives rise to very disagreeable odors. The discharge pipe from the cesspool empties into a neighboring creek.

Extending southeast from the main stable is a patch of ground 2 to 3 acres in extent, about five times as long as it is broad, inclosed by a fence. This is known as the cow yard. It slopes gradually down to within 10 to 12 feet of the creek into which the drainage from the stables is eventually discharged. In the lower portion of the cow yard the cattle are watered, the water being pumped from a spring into a long trough elevated about a foot from the ground.

The lower portion of the cow yard is also used as a dumping place for the leaves collected from various portions of the Home grounds, and when these become mixed with the droppings of the cattle and saturated with moisture a veritable swamp is formed, through which the cattle must pass to reach the water.

The manure from the stables was hauled each day to a place specially provided in the rear of the cow yard, where it remained at most a few days at a time. It was used to improve the condition of such portions of the Home grounds as needed fertilizing.

The spring from which the drinking water was obtained is apparently well removed from any source of contamination.

During the warm months the herd was kept constantly out of doors. At 4 a. m. the milch cows were driven into the stable, milked, turned into the cow yard with the other cattle, and from there the entire herd was driven into pasture. About 11 a. m. all the cattle were returned to the cow yard, the milch cows were again driven into the stable, milked, turned back into the cow yard, and from there, with the rest of the cattle, back into pasture. At 6 p. m. all the cattle were returned to the cow yard, where they remained until the following morning.

When the pasturage was not good the milch cows received a small amount of feed of one kind or another while in the stable to be milked.

During the cold months the cattle were not allowed to go into pasture, but were given fresh air and exercise in the cow yard, where they remained from one to eight hours, according to the state of the weather. The cows were milked at the same hours during the summer and winter. When not allowed to go into pasture the cattle were fed a mixture of cut beets, cut hay, and mill feed, one meal at 5:30 a. m. and another at 2:30 p. m., and a good feed of long hay in the evening. The quantity of the mixed feed varied according to the size and productivity of the animal, and was a half bushel at each feeding for a cow giving milk.

All the water for the cattle was obtained in the cow yard excepting only a small quantity which was mixed with the feed. This was from

a cistern supplied with rain water from the roof of the main stable, at the northeastern corner of which it was located.

No special restricted pasture was set apart for the cattle. A piece of ground from which the first crop of grass had been cut for hay was selected every day or two, and the cattle were confined to it by herds-men. Particular instructions were given the herds-men not to let the cattle drink from any creek or pond which might be near or in the pasture.

The bulls were never turned into pasture but were confined in inclosures of sufficient size to give them the needed exercise and air.

Shortly previous to the time of parturition the cows were placed in box stalls. The calves were allowed such portions of the milk of their dams as they needed during the first two months, after which they were fed cut hay mixed with meal or bran, or were turned out to pasture.

The cows were served by the bull three months after calving, so as to produce one calf every twelve to fourteen months.

When bedding was needed in the stalls it consisted of leaves collected on the Home grounds. No particular care was taken to train the cattle to occupy the same stalls at all times.

HISTORY OF TUBERCULOSIS IN THE HERD.

The first definite history of tuberculosis in the herd dates back to February, 1889. An inspector of the Bureau of Animal Industry was directed to examine the herd, and the result was that four Jersey cows were condemned as tuberculous. Post-mortem examination confirmed the diagnosis. Two of the cows were killed and examined at the Soldiers' Home and two sent to the veterinary station of the Bureau and kept under observation until the time of their death.*

When the above inspection was made the man in charge of the cattle was closely questioned in regard to diseases and deaths in the herd. The information obtained at this time was of a character to lead to the supposition that some of the former deaths were due to tuberculosis. The cattle were again examined by a Bureau inspector in the fall and winter of 1891 and 1892, and one Jersey heifer (No. 338) pronounced tuberculous.

November 14, 1892, the Holstein bull which entered the herd in 1886 was sent to the veterinary station of the Bureau. He had an offensive nasal discharge, and both submaxillary glands were greatly enlarged. Tuberculosis was suspected, but could not be definitely diagnosed, and hence a tuberculin injection was tried. The test was made November 15 and 16 and a positive reaction obtained. November 17 both submaxillary glands were cut out and found to be tuberculous.

December 9 and 10, 1892, and January 19 and 20, 1893, the bull was again tested with tuberculin and positive reactions obtained in both

* Bulletin No. 3 of the Bureau of Animal Industry, pp. 60-62, Nos. 155 and 156.

instances. He was killed January 26, 1893, and the post-mortem examination showed extensive tuberculosis.*

After the first tuberculin test of the bull had given a positive reaction and the excised glands had been found tuberculous, the view, which had been gaining strength for some time, that tuberculosis was very general in the herd assumed almost the character of a fact, and it was further supported by another careful examination of the cattle extending over two days at the beginning of December, 1893. Several undoubted cases of tuberculosis were diagnosed, three or four times as many more animals were distinctly to be looked upon with suspicion. The condition of a very large portion of the remaining cattle was such that a diagnosis of tuberculosis with the methods usually employed by the practical veterinarian could not be made. Yet they showed little irregularities of various kinds which made it impossible, in the presence of so much tuberculosis, to pronounce them certainly free from the affection.

With matters in this uncertain state it was concluded to seek more reliable results from a general tuberculin test, and this was all the more desirable because the Bureau had been seeking a favorable opportunity for some time to test the value of tuberculin as a diagnostic agent on a larger scale than had been previously possible.

TUBERCULIN TESTS.

A preliminary tuberculin test was made directly after the last examination of the herd. Five cows were selected and their temperature taken every two hours from 6 a. m. to 8 p. m. December 6, 1892. The following morning at 6 o'clock each animal received an injection of tuberculin under the skin on the left side of the neck, and the temperature was again taken every two hours until 8 p. m., and once in addition to this at 9 p. m. December 8 the temperature was again taken at 11 a. m. to determine whether it had returned to normal in the animals which had shown an elevation the previous day. (For the degrees of temperature, obtained per rectum, during the test, see table, p. 59.)

The substance injected was the regular "Tuberculinum Kochii" imported from Germany. It was used in a 10 per cent solution. The diluent was distilled sterile water to which one-half per cent of carbolic acid had been added. Each animal received a dose of the solution equivalent to 0.4 cc. of pure tuberculin.

The reactions following the injections were quite surprising, and implied the presence of even more tuberculosis than had been suspected. Two of the cows selected, Nos. 306 and 311, which were included in the preliminary test particularly because of their excellent condition and apparently perfect freedom from disease gave high reactions. Cows Nos. 303 and 314 were selected as well-developed cases of

* For the tuberculin tests and the post-mortem notes see p. 58.

tuberculosis, and in them the reactions simply confirmed the previous diagnosis. Cow No. 304 alone gave no reaction; she had long suffered from a cough and was regarded as a highly suspicious case. The post-mortem examinations made later on fully verified the results of the test.

More extensive tuberculin tests were begun February 1, 1893. In these it was determined to observe the cattle with sufficient care while under the influence of the tuberculin to detect, if possible, any symptoms which might present themselves in tuberculous animals in addition to the rise in temperature. To do this effectually the whole herd could not be tested at one time, and hence it was divided into sections, and the different sections tested successively until every animal, with the exception of only one, had passed through two tests. Sufficient time was always allowed to pass after the first injection before the second was made to avoid interference of the former with the latter.

The tuberculin used was of two kinds, respectively specified as tuberculin K and tuberculin S. The former has already been described in connection with the preliminary test. Tuberculin S was prepared in the chemical laboratory of the Bureau of Animal Industry by Dr. E. A. de Schweinitz, and was injected in a 12½ per cent solution.

During the test the cattle were treated as nearly as possible in the customary manner. Just before the test they were turned into the cow yard for an hour, where they had access to fresh drinking water, then they were driven into the stable where they remained until the conclusion of the test. The drinking water, which at other times was obtained in the cow yard, was brought to the cattle in the stable during the test, and on very cold days was slightly warmed by the addition of a quart or two of boiling water to three or four gallons of cold water.

For the first test 10 head of cattle were selected. Commencing 9 a. m., February 1, 1893, the temperature, pulse, and respiration of each animal were taken every hour until 9 a. m. the next morning, when each animal received an injection of tuberculin S, immediately after which the temperature, pulse, and respiration were again taken, and every hour from then on until thirty-two hours had passed.

March 15, 1893, a second lot of 14 head was selected and treated in precisely the same manner. (For a full description of each animal and the dose of tuberculin each received, see cattle Nos. 301 to 324, pp. 31-41; for the temperature, pulse, and respiration of the cattle during the test, see tables, pp. 60-65.)

An examination of the tables shows that a small, marked increase in the frequency of the pulse often accompanies the rise in temperature resulting from an injection of tuberculin, and that in many cases a greater frequency in the respiration also occurs. But there is nothing sufficiently characteristic about this to give it value as additional evidence of the presence or absence of tuberculosis. The same conclusion

was previously reached by other experimenters with tuberculin.* Consequently, in the following tests the condition of the pulse and respiration was not noted. It was further observed that in few if any cases the rise in temperature commenced before the sixth hour after the injection, and that little or nothing was to be gained by taking the temperature during the first six to eight hours. This fact led to a change in the hour of making the injection from 9 a. m. to 12 p. m., in order to overcome the unpleasant necessity of remaining with the cattle all night. The temperature was then taken every hour from 7 or 8 a. m. until 11 p. m. At 12 p. m. the injections were made, and taking the temperature after injection was commenced the following morning at 6 or 7 o'clock, from which time on it was taken hourly until 10 p. m.

Cattle bearing Nos. 325 to 337, inclusive, were injected with tuberculin K, March 21, 1893; cattle Nos. 338 to 346, inclusive, were injected with tuberculin K, March 27, 1893; cattle Nos. 347 to 353, inclusive, were injected with tuberculin S, April 12, 1893, and cattle Nos. 354 to 363, inclusive, were injected with tuberculin S, May 1, 1893. (For a description of each animal and the dose of tuberculin given, see cattle Nos. 325 to 363, inclusive, pp. 41-59; for the temperature of the cattle during the tests, see tables, pp. 66-69.)

The second injections were made on the following dates: March 21, 1893, cattle Nos. 301, 302, 305, 307, 308, 309, and 310 received each an injection of tuberculin K. March 27, cattle Nos. 312, 313, 315, 317, and 319 to 324 inclusive, received each an injection of tuberculin K.† April 12, cattle Nos. 318, and 328 to 337 inclusive, received each an injection of tuberculin S. May 1, cattle Nos. 339 to 353, inclusive, received each an injection of tuberculin S. May 25, cattle Nos. 325, 326, 327, and 354 to 363 inclusive, received each an injection of tuberculin S. The same date the following cattle also received a third injection of tuberculin S. The same date the following cattle also received a third injection of tuberculin S: Nos. 305, 308, 309, 315, 319, 320, 321, 322, 334, 336, and 339. (For the temperature before and after the second and third injections, see tables, pp. 69-74.)

Cow No. 338 was so far advanced in tuberculosis before the time for a second injection arrived that she was killed in practically a dying condition.

Of the 63 animals included in the entire series of tests, 60 were examined post-mortem, and in all but 7 lesions of tuberculosis were present.‡

Before we can determine in what measure the results of the tuberculin injections correctly indicated the presence or absence of a tuberculous

* Deutsche Zeitschrift f. Thiermed., XVIII (1891), p. 99, Arbeiten a. d. kaiserl. Gesundheitsamte, VIII (1892), p. 55.

† The 5 cows included in the preliminary test did not receive a second injection in the general tests.

‡ Three cows, Nos. 325, 326, and 327, included in the tuberculin tests, were not killed. They were private property, and strictly speaking, did not form part of the herd.

affection, we must form a more or less definite idea of what is in truth to be called a reaction. On this point little agreement apparently exists between different observers, which is not an extraordinary fact when we consider the marked normal variations in the temperature of milk cattle, the readiness with which the temperature of many animals is influenced by slight and frequently unrecognizable causes, the dissimilar conditions under which different herds live, the lack of constancy in the quantity of tuberculin injected, and the possible variations in the strength, purity, and state of preservation of the tuberculin used.

The elevation in the temperature necessary to constitute a reaction has variously been given from 0.5°C. to 1°C. * (0.9°F. to 1.8°F.). But it is not sufficient to consider merely the number of degrees the temperature after the injection rises above the temperature before the injection. The height reached by the temperature and the duration of the elevation certainly can not be disregarded. In estimating the reliability of the results from tuberculin injections where the temperature after the injection is low, Eber maintains that a rise of not less than 0.5°C. must occur, and be continuous during many hours, before the presence of fever can be conclusively affirmed. A low temperature after the injection is specified as 39.5°C. (103.1°F.).† This is a rule which we believe it is necessary to observe. As an aid in estimating the result of the present series of injections, two synoptic tables of the first and second injections, respectively, are given below. In these will be found the maximum temperature before and after injection, the number of hours between each injection and the first rise in temperature, the number of hours the temperature remained elevated, the difference in degrees in each case between the highest temperature before and after the injection, and the presence or absence of tuberculosis on post-mortem examination.

* Arbeiten aus dem Kaiserlichen Gesundheitsamte, VIII (1892), pp. 84-86. See also two footnotes in Deutsche Zeitschrift f. Thiermed., XVIII (1892), p. 325.

† *Ibid.* XVIII (1892), p. 322.

A.—First injection of tuberculin.

No. of animal.	Date of injection.	Kind and dose of tuberculin used.	Maxi- mum tem- perature before in- jection.	Maxi- mum tem- perature after in- jection.	Number of hours after the injection when the temperature first exceeded the maximum of the pre- vious day.*	Number of hours after the injection during which the tempera- ture was higher than the maximum of the pre- vious day.†	Ampli- tude of reaction.	Date when killed and examined post-mor- tem.	Absence or presence of tubercu- losis (+ present, — absent).
301	Feb. 2, 1893	0.25 cc. S.	102.0	106.8	7	18	5.8	Mar. 24, 1893	+
302	do	do	102.2	107.4	6	19	5.2	do	+
303	Dec. 7, 1892	0.4 cc. K.	102.5	107.0	8	10+	4.5	Mar. 18, 1893	+
304	do	do	102.2	102.6	.....	3	0.4	Apr. 21, 1893	+
305	Feb. 2, 1893	0.25 cc. S.	101.8	102.8	.....	3	1.0	June 29, 1893	+
306	Dec. 7, 1892	0.4 cc. K.	102.6	106.0	10	8+	3.4	Mar. 21, 1893	+
307	Feb. 2, 1893	0.25 cc. S.	102.4	107.6	8	17	5.2	Apr. 4, 1893	+
308	do	do	102.3	104.6	7	11	2.3	June 5, 1893	+
309	do	do	102.4	104.8	9	13	2.4	do	+
310	do	0.125 cc. S.	102.8	105.8	7	13	3.0	Apr. 4, 1893	+
311	Dec. 7, 1892	0.4 cc. K.	102.5	106.0	10	8+	3.5	Mar. 21, 1893	+
312	Mar. 16, 1893	0.25 cc. S.	103.0	105.2	6	17	2.2	Apr. 28, 1893	+
313	do	do	102.3	106.6	7	18	4.3	Apr. 7, 1893	+
314	Dec. 7, 1892	0.4 cc. K.	102.5	106.0	10	8+	3.5	Mar. 18, 1893	+
315	Mar. 16, 1893	0.25 cc. S.	102.4	106.8	6	16	4.4	June 1, 1893	+
316	do	do	102.6	106.2	10	13	3.6	Apr. 7, 1893	+
317	do	do	103.0	105.8	10	13	2.8	Apr. 21, 1893	+
318	do	do	103.2	107.4	7	16	4.2	Apr. 14, 1893	+
319	do	do	103.3	102.8	.....	.....	-0.5	July 3, 1893	+
320	do	do	102.6	104.2	12	7	1.6	June 15, 1893	+
321	do	do	102.2	103.4	13	7	1.2	June 29, 1893	+
322	do	0.2 cc. S.	103.0	103.0	13	6	0.5	July 3, 1893	+
323	do	0.25 cc. S.	103.5	106.4	10	12	2.9	Apr. 12, 1893	+
324	do	do	104.0	105.8	7	17	1.8	do	+
325	Mar. 21, 1893	0.4 cc. K.	102.0	102.0	.....	.....	0	Not killed.	+
326	do	do	102.8	102.8	.....	3	0.6	do	+
327	do	do	103.2	103.4	.....	1	0.2	do	+
328	do	do	102.0	104.2	7	13	2.2	May 12, 1893	+
329	do	do	103.0	107.5	7	16+	4.5	Apr. 28, 1893	+
330	do	do	102.2	105.8	9	14+	3.6	Apr. 25, 1893	+
331	do	do	102.0	106.2	8	15+	4.2	Apr. 18, 1893	+
332	do	do	102.4	107.1	7	16+	4.7	Apr. 14, 1893	+

* A minus sign after a number indicates that the temperature following the injection had already risen above the maximum of the previous day the first time it was taken after injection.

† A plus sign after a number indicates that the last time the temperature was taken after injection it was still higher than the maximum of the previous day.

A.—First injection of tuberculin—Continued.

No. of animal.	Date of injection.	Kind and dose of tuberculin used.	Maxi- mum tem- perature before in- jection.	Maxi- mum tem- perature after in- jection.	Number of hours after the injection when the temperature first exceeded the maximum of the pre- vious day.*	Number of hours after the injection during which the tempera- ture was higher than the maximum of the pre- vious day.†	Ampli- tude of reaction.	Date when killed and examined post-mor- tem.	Absence or presence of tubercu- losis (+ present, — absent).
333	Mar. 21, 1893	0.3 cc. K.	102.0	106.9	7—	16+	0 F.	Apr. 18, 1893	+
334	do	5.4 cc. K.	102.4	102.9	7—	8	4.9	July 6, 1893	+
335	do	do	102.2	107.8	7—	16+	0.5	Apr. 25, 1893	+
336	do	do	102.6	106.9	8	13+	3.4	June 1, 1893	+
337	do	do	102.6	103.5	9	14	2.9	Apr. 14, 1893	+
338	do	do	102.6	103.8	9	1	0.2	Apr. 4, 1893	+
339	Mar. 27, 1893	0.3 cc. K.	102.0	103.6	7—	16+	0.6	June 10, 1893	+
340	do	0.4 cc. K.	101.0	104.0	7—	16+	2.4	May 25, 1893	+
341	do	do	103.0	103.0	7—	16+	3.0	May 10, 1893	+
342	do	do	102.2	106.0	7—	16+	2.8	do	+
343	do	do	101.6	107.0	7—	16+	5.4	May 12, 1893	+
344	do	do	101.8	103.2	9	13+	2.4	May 16, 1893	+
345	do	do	101.6	106.9	7—	16+	5.3	May 12, 1893	+
346	do	do	101.8	106.4	10	14+	4.6	May 16, 1893	+
347	Apr. 12, 1893	0.2 cc. S.	102.8	106.8	9	15+	4.0	May 5, 1893	+
348	do	0.25 cc. S.	102.7	106.2	10	14+	3.5	May 3, 1893	+
349	do	do	102.6	106.7	7—	16+	4.1	May 5, 1893	+
350	do	0.35 cc. S.	101.6	106.0	9	13+	4.4	May 10, 1893	+
351	do	0.25 cc. S.	102.6	106.7	9	15+	4.1	May 3, 1893	+
352	do	do	103.0	106.2	12	13	3.2	May 10, 1893	+
353	do	do	102.6	103.8	12	15+	1.2	May 3, 1893	+
354	May 1, 1893	do	103.5	106.9	10	17	2.5	June 8, 1893	+
355	do	do	102.0	104.0	11	12+	2.6	do	+
356	do	do	102.8	103.4	12	11+	2.0	June 12, 1893	+
357	do	do	102.0	104.0	12	3	0.2	July 13, 1893	+
358	do	do	102.8	103.0	12	11+	3.6	May 27, 1893	+
359	do	do	103.2	107.3	7—	16+	4.1	June 15, 1893	+
360	do	do	102.4	102.8	10	1	0.4	July 6, 1893	+
361	do	do	102.6	105.8	10	13	3.2	May 27, 1893	+
362	do	do	102.8	104.8	8	13	2.0	June 12, 1893	+
363	do	do	103.2	106.0	11	10	2.8	June 19, 1893	+

* A minus sign after a number indicates that the temperature following the injection had already risen above the maximum of the previous day the first time it was taken after the injection.

† A plus sign after a number indicates that the last time the temperature was taken after injection it was still higher than the maximum of the previous day.

B.—Second injection of tuberculin.

No. of animal.	Date of injection.	Number of days since the first injection.	Kind and dose of tuberculin used.	Maxi- mum tem- perature before in- jection.	Maxi- mum tem- perature after in- jection.	Number of hours after the injection when the temperature first exceeded the maximum of the pre- vious day.	Number of hours after the injection during which the tempera- ture was higher than the maximum of the pre- vious day.	Ampli- tude of reaction.	Date when examined post-mor- tem.	Absence or presence of tubercu- losis (+ present, —absent).
301.	Mar. 21, 1893	47	0.4 cc. K.	102.7	106.5	7—	16+	3.8	Mar. 24, 1893	+
302.	do	47	do	102.2	106.8	7—	16+	4.6	do	+
303.	Feb. 2, 1893	57	0.25 cc. S.	102.0	105.6	7—	18	3.6	Mar. 18, 1893	+
304.	do	57	do	102.3	102.6	7—	1	0.3	Apr. 21, 1893	+
305.	Mar. 21, 1893	47	0.4 cc. K.	102.0	103.0	15	5	1.0	June 29, 1893	+
306.	Feb. 2, 1893	57	0.25 cc. S.	102.2	106.4	11	14	4.2	Mar. 21, 1893	+
307.	Mar. 21, 1893	47	0.5 cc. K.	103.0	106.3	7—	15+	3.3	Apr. 4, 1893	+
308.	do	47	0.35 cc. K.	102.2	103.0	7—	11	0.8	June 5, 1893	+
309.	do	47	do	102.4	104.0	16	3	1.6	do	+
310.	do	47	0.2 cc. K.	102.6	106.0	7—	11	3.4	Apr. 4, 1893	+
311.	Mar. 16, 1893	99	0.25 cc. S.	102.4	106.6	8	15	4.2	Mar. 21, 1893	+
312.	Mar. 27, 1893	11	0.4 cc. K.	102.0	104.8	7	16+	2.8	Apr. 28, 1893	+
313.	do	11	do	102.4	104.4	10	12	2.0	Apr. 7, 1893	+
314.	Mar. 16, 1893	99	0.25 cc. S.	102.6	107.0	7	14	4.4	Mar. 18, 1893	+
315.	Mar. 27, 1893	11	0.4 cc. K.	102.2	105.2	7—	13	3.0	June 1, 1893	+
316.	do	11	do	103.1	106.0	10	14+	2.9	Apr. 7, 1893	+
317.	do	11	0.3 cc. K.	102.8	102.7	7—	15+	0.1	Apr. 21, 1893	+
318.	Apr. 12, 1893	27	0.2 cc. S.	103.4	107.2	7—	15+	3.8	Apr. 14, 1893	+
319.	Mar. 27, 1893	11	0.2 cc. K.	103.0	103.0	7—	15+	0	July 3, 1893	+
320.	do	11	0.3 cc. K.	102.8	102.6	7—	15+	0.2	June 15, 1893	+
321.	do	11	do	102.5	102.0	7—	15+	0.5	June 29, 1893	+
322.	do	11	0.2 cc. K.	102.8	104.2	12	3	1.4	July 3, 1893	+
323.	do	11	0.3 cc. K.	103.4	105.2	7—	6	1.8	Apr. 12, 1893	+
324.	do	11	do	102.8	107.0	7—	16+	4.2	do	+
325.	May 25, 1893	65	0.25 cc. S.	102.8	103.0	17	1	0.2	Not killed.	+
326.	do	65	do	103.0	103.4	7—	1	0.4	do	+
327.	do	65	do	102.0	103.6	7—	14+	1.6	do	+
328.	Apr. 12, 1893	22	do	102.7	105.4	9	14	2.7	May 12, 1893	+
329.	do	22	do	103.4	105.8	7—	16+	2.4	Apr. 28, 1893	+
330.	do	22	do	102.0	105.2	7—	16+	3.2	Apr. 25, 1893	+
331.	do	22	do	101.8	105.8	7—	16+	4.0	Apr. 18, 1893	+
332.	do	22	do	102.8	106.2	7—	16+	3.4	Apr. 14, 1893	+
333.	do	22	do	102.4	105.6	9	9	3.2	Apr. 18, 1893	+
334.	do	22	do	101.8	102.5	16	5	0.7	June 6, 1893	+
335.	do	22	do	102.0	103.2	7—	12	3.2	Apr. 25, 1893	+
336.	do	22	do	102.8	104.9	12	12+	2.1	June 1, 1893	+

B.—Second injection of tuberculin—Continued.

No. of animal.	Date of injection.	Number of days since the first injection.	Kind and dose of tuberculin used.	Maxi- mum tem- perature before in- jection.	Maxi- mum tem- perature after in- jection.	Number of hours after the injection when the temperature first exceeded the maximum of the pre- vious day.	Number of hours after the injection during which the tempera- ture was higher than the maximum of the pre- vious day.	Ampli- tude of reaction.	Date when killed and examined post-mor- tem.	Absence or presence of tubercu- losis (+ present, — absent).
337.	Apr. 12, 1903	22	0.25 cc. S.	102.0	105.0	7—	16+	3.0	Apr. 24, 1903	+
338*									Apr. 4, 1903	+
339.	May 1, 1903	35	0.25 cc. S.	103.0	103.5	0	1	0.5	June 19, 1903	+
340.	do	35	do	102.2	102.6	14	4	0.4	May 23, 1903	+
341.	do	35	do	103.4	106.0	8	16+	2.6	May 10, 1903	+
342.	do	35	do	103.4	104.2	19	5	0.8	do	+
343.	do	35	do	102.6	106.2	7—	14	3.6	May 12, 1903	+
344.	do	35	do	102.4	102.0	7—	16+	0.4	May 12, 1903	+
345.	do	35	do	102.4	106.4	7—	16+	4.0	May 16, 1903	+
346.	do	35	do	102.6	103.5	12	9	0.9	May 16, 1903	+
347.	do	19	0.2 cc. S.	103.6	104.2	17	2	0.6	May 5, 1903	+
348.	do	19	0.25 cc. S.	102.2	103.2	12	10	1.0	May 3, 1903	+
349.	do	19	do	102.0	103.8	7—	16+	1.8	May 5, 1903	+
350.	do	19	0.35 cc. S.	102.2	105.0	12	11+	2.8	May 10, 1903	+
351.	do	19	0.25 cc. S.	102.4	105.6	7—	16+	3.2	May 3, 1903	+
352.	do	19	do	104.0	104.3	7—	10	0.3	May 10, 1903	+
353.	do	19	do	102.6	104.3	12	5+	1.7	May 3, 1903	+
354.	May 25, 1903	24	do	102.6	103.0	17	5+	0.4	June 8, 1903	+
355.	do	24	do	103.2	102.8	17	5	0.8	do	+
356.	do	24	do	102.0	102.8	17	5	0.8	June 12, 1903	+
357.	do	24	do	105.0	102.5	13	10	2.5	July 13, 1903	+
358.	do	24	do	101.8	102.9	13	10	1.1	May 27, 1903	+
359.	do	24	do	103.4	103.0	13	10	0.4	June 15, 1903	+
360.	do	24	do	102.2	102.5	13	1	0.3	June 6, 1903	+
361.	do	24	do	102.4	102.5	13	1	0.1	July 6, 1903	+
362.	do	24	do	102.4	103.0	16	4	0.6	May 27, 1903	+
363.	do	24	do	102.8	102.7	16	4	0.1	June 12, 1903	+
								—0.1	June 19, 1903	+

* Received no second injection.

Table A gives the result of the first injections. The absence or presence of a reaction supported by the absence or presence of tuberculosis is so clear in 50 of the 60 animals examined post-mortem that they require no special attention. This leaves 10 animals of more doubtful character, which we will consider in order (see pp. 31-58 for complete notes):

No. 305.—The maximum temperature after injection, which is 102.8° F., is not sufficiently high, although it is 1° F. above the maximum temperature previous to injection, to pass as a reaction in a herd of 63 cattle among which 18 gave a maximum temperature of 102.8° F. or more before injection. Neither is the elevation in the temperature after injection over and above the maximum temperature before injection (only three hours) of sufficient duration to be regarded as a reaction. Hence the absence of tuberculosis in this animal was properly indicated by the tuberculin injection.

No. 319.—Failed to give a reaction and on post-mortem examination was found tuberculous. The tuberculous foci were small, largely calcareous, and the surrounding tissue free from recent infiltration.

No. 320.—Gave a low reaction in the absence of tuberculosis. The animal is a heifer, which had been served by the bull every three weeks for five or six months previous to the date of conception, February 15, 1893, just one month before the injection.

No. 321.—The highest temperature reached after injection was 103.4° F., and although this is 1.2° F. above the maximum temperature of the previous day, in consideration of the fact that the animal was seven months advanced in her first pregnancy, it is not sufficient to constitute a reaction. On post-mortem no tuberculosis was found, but the animal was affected with a liver disease.

No. 322.—No reaction and tuberculosis present. The lesions are similar to those in No. 319.

No. 334.—No reaction and tuberculosis present.

No. 338.—No reaction and very extensive tuberculosis present.

No. 340.—A decided reaction and no tuberculosis. The animal was supposed to be four months and ten days advanced in pregnancy at the time of the post-mortem examination, one month after the tuberculin test, but in her uterus was found a fetus, about three months old, dead and partly disintegrated.

No. 353.—Will have to pass as a case showing no tuberculosis on post-mortem, but giving a very low or somewhat doubtful reaction.

No. 360.—No reaction and tuberculosis present. Similar to Nos. 319 and 322. A guinea pig inoculated died from tuberculosis in two months.

Thus we have 52 instances out of 60 in which the presence or absence of tuberculosis was correctly indicated by the use of tuberculin as a diagnostic agent, giving a general average of $86\frac{2}{3}$ per cent.

It is questionable whether the absence of reactions in cases Nos. 319, 322, and 360 should have much weight. They must, indeed, be ranked as failures, but they were in all probability stationary cases of disease, dangerous neither to themselves nor other cattle. It is also interesting to note that the two animals without tuberculosis, which must be regarded as having given a reaction, Nos. 320 and 353, show a feeblor reaction, which commenced at a later hour and was of shorter duration than the reaction in any animal decidedly tuberculous.

The standard of what should constitute a reaction could conveniently be raised high enough for the herd to exclude these two cases from the number of animals giving a reaction without increasing the number of animals found tuberculous without a reaction.

An examination of Table B, which gives the results of the second injections, will show that the first part corresponds very well with Table A. The results in the latter portion of the table are not reliable, a fact for which we can account at the present time only by assuming the existence of some defect in the tuberculin used.

Since the above was written several instances have come under observation where a second injection failed altogether to produce a reaction in animals which gave a very decided reaction after the first injection, notwithstanding that the two injections were separated by a very considerable period of time.*

OTHER CONDITIONS ASSOCIATED WITH THE TUBERCULIN INJECTIONS.

Swelling and tenderness at the seat of injection, sufficiently severe to be clearly noticeable, were present in less than 20 per cent of the cattle, and were as common among the nontuberculous which gave no reaction as among the tuberculous animals which reacted.

Muscular trembling or shivering, as if from a severe chill, noticeable especially in the flank, was a common occurrence. It was seen in 25 to 30 animals, either after the first or second injection; some cattle showed this condition after the first injection and not after the second, and *vice versa*. It accompanied as a constant feature neither the highest reactions nor those of longest duration, nor was it confined to animals with lesions of a particular kind in character or extent. The most interesting feature about it is that wherever it was seen lesions of tuberculosis were found on post-mortem examination.

A decided softening of the feces, an acceleration of the pulse and respiration, arching of the back, coldness of the hind quarters and extremities, loss of appetite and temporary suspension of rumination, the latter during the time the fever was greatest, are conditions which were observed in a considerable number of animals, but like the swelling and

*Quite recently 6 cows received an injection of tuberculin, which was followed in twenty-four days by a second injection. The following table gives the results of the two injections. For the first injection tuberculin S was used; for the second tuberculin K. Only one animal (No. 5) included in the table was pregnant; it was her fourth pregnancy, in which she was five months advanced at the time of the last injection. It is to be regretted that the animals included in the table could not have been killed and examined post-mortem.—E. C. S.

No. of cow.	Highest tempera- ture be- fore first injection.	Highest tempera- ture after first in- jection.	Highest tempera- ture be- fore sec- ond in- jection.	Highest tempera- ture after second injection.	Reaction after first in- jection.	Reaction after second injection.
	° F.	°	°		° F.	° F.
1	102.8	106.2	101.9	104.8	3.4	2.9
2	104.0	106.5	101.7	102.0	2.5	0.3
3	102.8	104.0	102.3	105.1	1.2	2.8
4	101.4	104.8	101.8	106.4	3.4	4.6
5	101.8	104.0	102.4	104.7	2.2	2.3
6	102.6	106.0	102.1	104.0	3.4	1.9

tenderness at the seat of injection, they have apparently no practical significance.

So far as it was possible to observe, no unfavorable condition was produced in any animal by the tuberculin injections. In regard to this matter most observers are agreed.*

A reduction in the milk secretion, if this occurred, was only temporary, and too small in amount to attract attention in a large herd of which only a comparatively small number of cattle were under the influence of the tuberculin at one time. It is reasonable to suppose that the quantity of milk from cattle affected by a loss of appetite was slightly diminished in consequence of the smaller amount of food consumed. The reduction in the milk secretion observed in cattle tested with tuberculin in Karlsruhe and Mannheim was attributed to this cause and to the disturbance of the animal while undergoing the test.† A decided reduction in the milk secretion was observed in cattle tested in Berlin, but the specific gravity of the milk remained unaffected.‡ §

* Deutsche Zeitschrift f. Thiermed, XVIII (1891), p. 97. Arbeiten a. d. Kaiserlichen Gesundheitsamte, VIII (1892), p. 86.

† *Ibid.*, p. 86.

‡ *Ibid.*, pp. 40, 41.

§ The amount of milk secreted by 65 to 70 cows in a herd of 134 cattle which were injected with tuberculin in Virginia was 800 pounds the day before and 750 pounds the day after the injection. In 71 per cent of the herd the injection was followed by a reaction.

Unfortunately this herd could not be kept under observation a longer time than the tuberculin test actually required to determine the number of animals affected with tuberculosis, and hence no exact data could be secured on the amount of milk secreted by the cows during the first eight to ten days after the injection. On this last point the manager of the herd informs me that a reduction in the amount of milk commenced the day after the injection, that it was progressive during several days, and reached its climax the fourth or fifth day, and that the daily amount of milk then increased again until it reached its normal about the tenth day.

In this connection the following table may be of interest. It includes 6 cows, each of which was injected with 0.3 cc. of tuberculin K. The amount of reaction (the difference between the highest temperature the day before and the day after the injection) is given in degrees F., and the amount of milk in pounds the day before and after the injection.

No. of cow.	Amount of reaction.	Milk before injection.	Milk after injection.	Reduction in milk after injection.
1.....	2.9	16.1	15.0	1.1
2.....	0.3	27.1	27.8	-0.7
3.....	2.8	17.7	16.2	1.5
4.....	4.6	22.5	17.1	5.4
5.....	2.3	17.3	17.1	0.2
6.....	1.9	30.9	29.1	1.8
Total ....	.....	131.6	122.3	9.3

Of the above cows all, except No. 5, had calved within the last two to five months, and were not pregnant. No. 5 had calved eight months previous to the test and was five months advanced in pregnancy.

In another herd in Virginia, in which 15 cattle were injected with tuberculin, and 70 per cent of the milk cows reacted, a marked reduction in the amount of milk yield during the first few days after the injection was reported.—E. C. S.

In our test we made no examination of the urine. In the Berlin tests already referred to it was observed that the specific gravity remained uninfluenced, but that the alkalinity and the amount of sodium chloride were increased in almost every case, in tuberculous as well as non-tuberculous cattle. This condition was very marked the second day after the injection, and reached its highest point the fourth day. The increased alkalinity and the increased amount of sodium chloride did not keep pace with each other, so that when the alkalinity had reached its highest point a reduction occurred in the sodium chloride and inversely.*

All the injections with tuberculin in cattle published up to March 15, 1892, have been included in a general résumé by A. Eber.† He describes the various conditions it is necessary to observe in experiments the purpose of which is to determine the value tuberculin possesses as a diagnostic agent in tuberculosis. The conditions are much the same as those now generally accepted, and correspond fairly well with the conditions we have observed in our work. After applying them to the tuberculin injections with which his résumé deals, he finds 443 cases sufficiently free from objectionable features to answer as material for reliable conclusions. Of the 443 animals injected, the condition as regards tuberculosis was correctly determined in 375 cases, which is equivalent to 15.35 per cent of failures. The result of the first injections in the Soldiers' Home herd compares favorably with this, and while it is a rate of failures too high to give more than partial satisfaction, it is so great an improvement over all other known methods by which tuberculosis can be diagnosed that the importance of tuberculin can hardly be too highly estimated. It must also be borne in mind that the eight animals in the Soldiers' Home herd in which the tuberculin is represented as having given false results are, with one exception, involved in a degree of doubt. Nos. 319, 322, 334, and 360, which gave no reaction, certainly were not free from lesions of tuberculosis, but in 3 of the 4 animals there was no recent infiltration, and if the lesions in all four animals had been concentrated in only one animal, they would still have been too slight to have given the remotest intimation of their presence where their detection depended on the usual methods of examination. The absence of tuberculosis in Nos. 320, 340, and 353 is questionable in the presence of the reaction after injection with tuberculin, in the sense that absence here may mean, simply, not found after careful search. Because of economical considerations the carcasses of the cattle in which the lesions were slight, or apparently absent, were not mutilated to any extent which would have destroyed their value as food.

The absence of a reaction in No. 338 is peculiar; it was an advanced case of tuberculosis, in which the affection was readily diagnosed almost

* *Ibid.*, p. 55.

† *Deutsche Zeitschrift f. Tiermedizin*, xviii (1892), p. 321.

a year previous to the injection. Other observers have noticed that occasionally very advanced cases of tuberculosis fail to react, and that the reaction is frequently highest in young animals in the first stages of the disease.*

CONCLUSIONS AND SUGGESTIONS.

It is not necessary to repeat the many favorable opinions expressed by different observers in support of the value which is claimed for tuberculin as an aid in diagnosing doubtful cases of tuberculosis in cattle. The number of instances in which the conditions indicated by the results of the injections do not conform to the conditions found on post-mortem examination is so many times less the number of errors from all other methods used to diagnose tuberculosis, and there are so many cases of tuberculosis which could not possibly be detected by any other method, that even they who are least inclined to favor the use of tuberculin can not fail to recognize its importance.

The precise composition of tuberculin is unknown, its exact qualities have not been determined, and the methods used to test its strength and purity are imperfect. With further improvement in these respects we may expect more accurate results from tuberculin injections in the future.

To make a tuberculin test for practical purposes we believe it necessary to observe the following rules. In laying down these few simple rules we have kept in mind that it is desirable, from an economical point of view, to strip every test for practical purposes of all unnecessary labor or expenditure of time.

The temperature of the animals to be tested should be taken every two hours at least six or seven times before the injections are made, because without a knowledge of the variations before the injections it is frequently impossible to estimate correctly the value of the elevations after the injections. This precaution may have the appearance of an unnecessary waste of time and labor where the temperature before the injections varies only within what are usually regarded strictly normal limits for cattle. But the temperature does not always confine itself within these limits, and strictly normal limits for one herd and one set of conditions are not strictly normal limits for all herds and all conditions, and the exceptions, which certainly can not be justly neglected, can be selected only by a number of accurate measurements.

The importance of this rule will become more apparent if we turn to the temperature tables and examine the temperature previous to injection of the 14 animals in which a height of 103° F. was reached.

The following table gives the numbers of the 14 animals, the highest point reached by the temperature before the injection and the hour in which that point was reached, the temperature of each animal at 9

* Arbeiten a. d. kaiserlichen Gesundheitsamt, VIII (1892), pp. 54 and 55. The Journal of Com. Med. and Vet. Arch., Vol. xv (1894), p. 13.

a. m. the same day, and the difference in degrees between the highest temperature and the 9 a. m. temperature.

No. of animal.	Highest temperature before the first injection and the hour of occurrence.	Temperature, 9 a. m., before first injection.	Difference between the highest and lowest.	No. of animal.	Highest temperature before the first injection and the hour of occurrence.	Temperature, 9 a. m., before first injection.	Difference between the highest and lowest.
	° F.	°	°		° F.	°	°
312	103.0—4 p. m.	100.0	3.0	329	103.0—6 p. m.	100.6	2.4
317	103.0—5 p. m.	101.0	2.0	338	103.6—2 p. m.	102.2	1.4
318	103.0—6 p. m.	98.8	4.2	342	103.0—10 p. m.	101.8	1.2
319	103.3—5 p. m.	99.8	3.5	352	103.0—6 p. m.	102.6	0.4
323	103.5—5 p. m.	99.7	3.8	354	103.5—6 p. m.	101.8	1.7
324	104.0—5 p. m.	101.0	3.0	359	103.2—6 p. m.	101.2	2.0
327	103.0—11 a. m.	102.8	0.2	363	103.2—6 p. m.	101.9	1.3

We have here 14 animals which, with the exception of Nos. 324, in the last stages of pregnancy, and 338, a case of tuberculosis diagnosed previous to the test, gave no evidence of an affection or a condition accompanying which a great variation in temperature, or an unusually low or high temperature, could be expected; and yet, if these animals had received an injection of tuberculin between 9 and 10 a. m., the day the temperature in the tables was taken, and the presence or absence of a reaction later in the day had been determined from the state of the temperature at 9 a. m., even if the tuberculin in the supposed injections had been absolutely inert, at least three-fourths of the animals would have been looked upon as giving decided reactions.

The degrees of temperature above given were all taken previous to the first injections. If we now turn to the temperature of the same animals taken previous to the second injections, we find that in eight of them very similar variations exist, and that only two of them have a really normal temperature, showing clearly that in many individuals the variations are sufficiently constant to make their determination by precise measurements practically necessary in every tuberculin test from which reliable results are expected. In other words, the variation in the temperature of an animal during the course of a day is frequently so great that, if this variation is not determined, and the temperature is taken only once previous to a tuberculin injection, it is merely a matter of chance if a high temperature, natural to the animal and independent of the action of the tuberculin injection, is not confounded with or erroneously taken for a reaction.

Special stress is laid on this point because, in a recent article which speaks of the use of tuberculin, the opinion is expressed that while a long series of temperatures before injection may be more scientific, a single temperature before injection at 9 p. m. is sufficient for practical purposes.*

An examination of the degrees of temperature of the 24 animals included in Tables II to IX, which were taken during twenty-four con-

* The Journal of Comp. Med. and Vet. Arch., xv (1894), p. 12.

secutive hours previous to injection, will show that the maximum daily temperature was reached four times at 8 a. m., twice at 3 p. m., eight times at 4 p. m., eight times at 5 p. m., once at 6 p. m., and once at 9 p. m. The minimum temperature, with two exceptions, occurred before the hour of noon. Hence, while it is probable that the chances for error with a single temperature before the injection are less when that temperature is taken in the evening, or, better still, in the afternoon between 4 and 5 o'clock, it is clear, with the maximum daily temperature varying in the hour of its occurrence all the way from 8 a. m. to 9 p. m., that the hour at which a single temperature is taken does not signify much, and that it is insufficient in many, if not in all, cases for reliable conclusions.

Next comes the tuberculin, and this unfortunately, which is the most important consideration, is beyond the control of the inspector. The domestic tuberculin, with which our experience is largest, has certainly shown some peculiarities which are best explained by assuming a variation to exist in the strength of preparations of different dates. The imported tuberculin has given fairly constant results in our hands, but we have not used it with sufficient frequency to say that it is better than the domestic article. Dr. Curtice, whose experience with the foreign substance is more extensive, gives some reasons to doubt the constancy of its strength.*

The tuberculin should be properly diluted. One part of tuberculin to 9 parts of water containing from one-half to 1 per cent of carbolic acid has found general favor. The tuberculin prepared by the Bureau of Animal Industry is diluted in the form of a $12\frac{1}{2}$ per cent solution before it leaves the laboratory, and is ready for injection as received.

The dose, if the tuberculin is of the usually supposed strength, is from 4 to 5 cc. (about 1 to $1\frac{1}{4}$ drams) of the 10 per cent solution of the imported tuberculin, or from 2 to $2\frac{1}{2}$ cc. (about one-half to three-fourths dram) of the $12\frac{1}{2}$ per cent solution of the Bureau tuberculin, for an adult animal of medium size. In our work we have found the Bureau tuberculin to be a little stronger than the German tuberculin.†

The point at which the injection is made seems immaterial. The most convenient place is the side of the neck where the skin is thin, and a large, strong needle gives much more satisfaction than a small, fine one.

After the injection the temperature should again be taken in eight or ten hours, and from then on every two hours until a decided reaction, continuous during several hours, has occurred, or until eighteen or twenty hours have passed since the time of the injection.

In the Soldiers' Home herd the temperature, which commenced to rise before the tenth hour, generally remained elevated from ten to sixteen hours. The temperature, which remained practically equivalent

* The Journal of Comp. Med. and Vet. Arch., xv (1894), p. 13.

† Quite recently other veterinarians have been using very small doses -

to the temperature of the previous day until fourteen or sixteen hours after the injection, never rose high enough or retained its elevation long enough to be taken as a reaction. Nothing will be lost, therefore, by waiting ten hours before taking the first temperature after the injection, or by discontinuing to take the temperature after eighteen to twenty hours.*

In a number of tests made by us for practical purposes only, the temperature of the cattle was taken before the injections every two hours, from 8 a. m. to 8 p. m. The injections were made at 10 p. m. and the temperature after the injections was again taken the following day at 8 a. m., and continued every two hours until 8 p. m. In the herds tested in this manner only the animals which gave reactions were killed, and thus far we have yet to meet the first case which reacted and did not show tuberculosis on post-mortem examination.

PATHOLOGICAL PART.

By THEOBALD SMITH.

The post-mortem examinations of the sixty animals in this herd were made by the writer with the assistance of Drs. Kilborne and Schroeder. Great care was exercised in order that accurate information might be gained concerning the true significance of the results obtained with tuberculin published in the preceding pages. Incidentally, however, a number of interesting facts were observed, some of which have been casually mentioned by other writers, but without that emphasis which is due them as elucidating the channels of infection. Fortunately many of the animals were still in that stage of the disease which permitted the accurate determination of the original focus of infection. Autopsies upon tuberculous cattle are made mainly when the tubercular virus has become pretty generally disseminated through the lymphatic glands and even over the serous membranes and through the various vital organs. A determination of the point in the body whence the virus has spread is, in many of these cases, out of the question. On the other hand, when the disease is in an incipient or quiescent stage it is hidden away in the lymphatic glands, and unless a thorough search is made through every gland in certain regions of the lymphatic system, the disease may be overlooked. This search is not likely to be made on general principles, for it is exceedingly tedious, and not usually of any definite value in diseases other than tuberculosis.

The autopsies in the herd under investigation were limited to the head, the thorax, the abdomen, and the glands of the limbs. Owing to the amount of time spent in searching through the other parts of the body, the brain was not examined in all cases. Inasmuch as this

* When very small doses of tuberculin are used these rules may not hold.

organ is not likely to be primarily affected, and tuberculosis of the central nervous system is quite rare, the inferences and conclusions that may be drawn will not be affected by this omission.

Before discussing the lesions more in detail I deem it desirable to call the attention of the reader to pages 139 and 140, which give, in tabulated form, the distribution of the disease in the body as shown by the organs and structures involved. The table needs no explanation beyond the statement that the entire distribution of the disease is given, nothing being omitted which came to light at the autopsy. The diagnosis, where any doubt existed, was made by the microscopic examination of sections. In several cases guinea-pigs were inoculated to test the vitality of the virus in cheesy material.

The first thing that will strike the reader as remarkable in looking over these tables is the high percentage of infection in a herd in which not more than 5 or 6 showed evidence of disease. The concealed character of the affection was not always limited to the very mild infections, but in some cases considerable lung disease remained unobserved during life. Of the 60 animals killed only 7, or about 12 per cent, were free from all traces of tuberculosis. In the remaining 53 the disease varied very much in intensity, ranging from the smallest, probably quiescent focus in one of the thoracic glands, to advanced tuberculosis.

In order to present these cases more intelligibly I shall discuss, in the order named, (1) tuberculosis of the glands of the head and neck, (2) of the thoracic organs, and (3) of the abdominal organs.

In the head the disease was restricted mainly to the retro-pharyngeal glands (*Glandulae tracheales seu cervicales superiores [profundae]*). These glands are easily reached after removing the tongue, and it is convenient to remove them together with the tonsils for examination. From the table it will be seen that these glands were diseased in 9 cases (17 per cent). In 5 they contained the only foci discoverable. In the remaining 4 disease of other structures also was present. The submaxillary lymph glands were free in all cases. In one case (No. 315) the tonsils and one parotid lymph gland were tuberculous.

The retro-pharyngeal glands, situated dorsad and to one side of the pharynx and larynx, receive the afferent lymphatic vessels from the parotid and the submaxillary lymph glands* and hence the territory drained by the lymphatic vessels, which finally enter these glands, includes the mucous membrane of the mouth and nose, in other words, of the entire portion of the respiratory and digestive tract lodged in the head and upper portion of the neck.

In the five cases in which tuberculosis of the retro-pharyngeal glands was the only discoverable focus (Nos. 309, 315, 329, 344, and 352), the tubercle bacillus must have been carried from the mucous membrane of the mouth, nose, tonsil, or pharynx into the gland. We do not know, therefore, whether the virus was deposited from respired air *or* taken

* Encyclopädie der gesammten Thierheilkunde, vi, 216.

in with the food. Infection of these glands, however, is generally regarded as introduced with the food. In case of No. 337 there was also lung disease, and it is impossible to determine whether the infection was primary or due to bacilli coughed up from the lungs. The same may be said of No. 343.

In No. 363, on the other hand, the infection of this gland was probably independent of the infection of the thoracic glands. The number of cases of tuberculosis which may be overlooked, if these glands are not examined, is by no means insignificant. In the herd under discussion the 5 animals affected with primary tuberculosis of the glands of the head (about 9 per cent) did not manifest during life any difficulties in breathing. In fact, the glands had not become large enough to cause any obstruction to respiration or deglutition.

The disease in the *thoracic organs* is of considerable interest to us, for it confirms the statement made by other observers that most cases of bovine tuberculosis are of pulmonary origin. This means that tubercle bacilli are taken up mainly in the dried condition and carried by currents of air as dust into the ramifications of the air tubes.

A glance at the table shows that out of fifty-three cases of tuberculosis, forty-seven, or 88.6 per cent, were affected with tuberculosis of organs situated in the chest. The disease involved one or all of the following structures: Bronchial glands, mediastinal glands, lung tissue (including air tubes), pleura.

The distribution of the lesions is of considerable interest. The lungs themselves were affected in 20 animals, while the other 27 had lesions in either bronchial or posterior mediastinal glands, or both, without lung disease. Taking it for granted at present that in nearly all cases the tubercle bacilli which are lodged in the bronchial and mediastinal glands have passed through the lungs, the great predominance of pulmonary infection, as compared with other channels of infection in this herd, becomes evident.

It is of considerable importance to note that of 47 animals having tuberculous lesions in the thorax, 27 had only gland tuberculosis. If, in other words, the lungs only had been examined and the lymph glands associated with them neglected, either in part or as a whole, 48 per cent of the cases would have been passed as free from tuberculosis. In a few of these, however, the mesenteric glands were likewise affected, so that some might have been detected from these foci.

Turning to infection, by way of the *digestive tract*, we may note at the outset that of the 53 infected animals only one had tuberculous lesions of the mucous membrane of the small intestine. In this case (No. 338) tuberculosis had become generalized over the entire lymphatic system, the lungs were almost completely converted into tuberculous masses and the serous membranes of thorax and abdomen were studded with them. The animal was very weak and lying down most of the time shortly before it was killed. Nevertheless, there was no

macroscopic evidence of generalized tuberculosis, for the parenchyma of liver, spleen, and kidneys was free from visible tuberculous lesions. The intestinal infection consisted of an infiltration of all Peyer's patches, followed by marked thickening of the walls and subsequent ulceration. The borders of the excavated patches were thickened until the latter assumed a decided boat-shaped outline. The mesenteric glands were very large and completely caseous.

Infection by way of the intestinal tract was indicated in fourteen cases by tuberculosis of a smaller or larger number of mesenteric glands.

To these should be added three cases in which only the portal system was infected and in which the infection probably came from the digestive tract. There were, therefore, in all eighteen cases with tuberculous lesions, resulting from an entrance of the bacilli by way of the intestines. The question whether this infection was primary, or secondary to disease of the lungs is worthy of consideration and may be partially answered by an examination of the individual cases.

In the severe case with tuberculous ulceration of Peyer's patches the tubercle bacilli probably came from the lungs. That they were discharged in abundance was demonstrated by the condition of the larynx and trachea. The mucous membrane of this tube was densely packed with tubercles, so as to form a compact elevated layer. The tubercle bacilli coughed up from the lungs produced tuberculosis of the trachea and when swallowed the bacilli attacked the intestinal walls. Among the remaining seventeen cases there are some (Nos. 307, 335, 347, 348, 355, and 358) in which the infection must be regarded either as independent of or simultaneous with the chest affection, since it would be impossible to explain how tubercle bacilli could travel from a closed focus in the bronchial and mediastinal glands to the mesenteric or the portal glands, and to them only.

There is but one case (No. 333) in which there was intestinal infection without lung infection.

The cases that still remain are all associated with disease of the lungs (Nos. 303, 306, 311, 314, 318, 324, 336, 337, 339, and 362). In these the infection of the mesenteric glands and the liver may have been contemporaneous with the lung infection. Of the tubercle bacilli introduced into the body at the same time some may have found their way into the digestive tract, others into the lungs. A perusal of the autopsy notes will show, however, that, at least in some of these cases, the intestinal infection is more recent and much less pronounced than the lung infection, and may have been brought about by swallowing tuberculous matter coughed up from the air tubes.

The infection of the liver or the lymph glands at the hilus, already mentioned above, was observed in nine cases. In six of these the infection of the liver was associated with tuberculosis of the mesenteric glands, and hence it is reasonable to regard them as both originating in the digestive tract. Of the three cases remaining, two showed tuber-

culosis of the glands at the hilus, and in one the liver contained a large tuberculous focus. These were probably of intestinal origin, for the infection of the body as a whole was either very slight (Nos. 307, 335) or else traceable to pulmonary disease (No. 324).

The infection by way of the lungs was, therefore, much more prevalent in this herd than infection by way of the intestines, the ratio being as 2.6 to 1, even if we regard all the cases of intestinal infection as primary, which I think no one will concede. In fact, the ratio is probably nearer 5 to 1.

A point very important from the standpoint of prevention is the condition of the bacilli when entering the body. Primary lung infection can not take place unless the bacilli are inspired with the air. They must, therefore, be dried and carried as dust. Hence in 88.6 per cent of the cases the infection, either as a whole or in part, was caused by dried bacilli capable of floating in the air.

The udder was found free from tuberculous deposits in all cases. In one, however (No. 303), there were large caseous foci in the pubic or udder lymph glands. These are evidence of a former infection of the udder itself. Taking this and all other cases of equal severity into consideration I am inclined to look upon this infection as internal in origin, that is, carried to the udder in the blood from some other focus, and not as a result of infection from without. There was no sign of uterine infection in any animal.* In several cases of advanced tuberculosis of the appendages of uterus (ovaries and Fallopian tubes) and slight tuberculosis of the uterus itself which have come under my observation during the past three or four years the infection evidently traveled from the peritoneum, which was extensively diseased in such animals.

A summary of the disease in this herd, grouped with regard to the distribution of the lesions, is presented in the following table:

Total number of animals in the herd examined.....	60
Total number of animals infected (88 per cent).....	53
Number in which retropharyngeal glands only were affected.....	5
Total number in which retropharyngeal glands were affected.....	9
Number in which disease of the thoracic organs was detected.....	47
Number in which lungs were affected.....	20
Number in which thoracic glands but not the lungs were diseased.....	27
Number in which only bronchial glands were affected.....	5
Number in which only mediastinal glands were affected.....	5
Number in which lungs diseased and glands healthy.....	1
Number with exclusively thoracic lesions (air infection).....	26
Number in which digestive tract, including head glands, affected.....	26
Number in which intestinal walls were affected.....	1
Number in which mesenteric glands were affected.....	16
Number in which portal glands were affected.....	10
Number in which mesenteric and not portal glands affected.....	10

* The very advanced case (No. 338) was not examined with reference to this organ.

Number in which portal and not mesenteric glands affected.....	4
Number in which parenchyma of liver involved.....	2
Number in which serous membranes affected.....	2
Number in which udder glands affected.....	1

SUMMARY OF TUBERCULIN REACTION AND AUTOPSY NOTES.

[The clinical notes and the tuberculin reactions were supplied by Drs. Kilborne and Schroeder.
For the autopsy notes Dr. Smith is responsible.]

No. 301.—Cow, three-fourths Holstein, 4 years old. Weight, 850 pounds. Calved summer of 1892; still giving milk. Pregnant since August 21, 1892. Condition good.

February 2, 1893: 9 a. m., first injection, 0.25 cc. tuberculin S.; 6 to 7 p. m., periods of trembling observed. Feces softened and passed more frequently than usual. Before injection, minimum temperature, 100.1° (10 a. m.); maximum, 102° (3 p. m.). After injection, minimum temperature, 101.2° (1 p. m.); maximum reached in twelve hours, 106.8° (9 p. m.). (For complete record see p. 60.)

March 21, 1893: Midnight, second injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 102.7° (4 p. m.);* after injection, reached in sixteen hours, 106.5° (4 p. m.). (For complete record see p. 69.)

March 24, 1893: Killed for examination.

Autopsy.—Thorax: All the bronchial and posterior mediastinal glands infected. The disease appears as foci of grayish infiltration in which are delicate networks of yellowish lines (necrosis). The foci are up to one-half inch in diameter and all appear to be in about the same stage.

Lungs: Trachea and bronchi free from any visible tuberculous changes.

Abdomen: One mesenteric gland contains a focus about three-eighths inch in diameter completely transformed into gritty particles.

One gland at the portal fissure contains a tuberculous focus about one-half inch in diameter in which the disease process is perhaps somewhat farther advanced than in the bronchial glands.

No. 302.—Holstein cow, 5 years old. Weight, 850 pounds. Calved July, 1892; still giving milk. Pregnant since September 30, 1892. Condition good.

February 2, 1893: 9 a. m. first injection, 0.25 cc. tuberculin S.; 5 to 10 p. m., pulse fuller and stronger than before injection. Respiration somewhat accelerated. Feces softened. Before injection, minimum temperature, 100° (9 a. m.); maximum, 102.2° (4 p. m.). After injection, minimum temperature, 101° (1 p. m.); maximum, reached in ten hours, 107.4° (7 p. m.). (For complete record see p. 60.)

March 21, 1893: Midnight, second injection, 0.4 cc. tuberculin K.

March 22: 10 a. m., periods of slight trembling observed. Before injection, maximum temperature, 102.2° (6 p. m.); after injection, reached in twelve hours, 106.8° (12 a. m.). (For complete record see p. 69.)

March 24, 1893: Killed for examination.

Autopsy.—Thorax: The caudal two-fifths of right caudal lobe of lungs completely tuberculous. The disease appears most advanced along the cephalic border of the involved mass. Here the lung tissue is transformed into soft caseous masses containing some gritty particles, which are over one-half inch in diameter and inclosed in connective tissue capsules. Toward the caudal extremity of the lobe the foci are yellowish, necrotic, but not yet broken down, excepting in a few cases. The bronchus contains a few soft grayish and some caseous tubercles breaking through the mucosa. There are several cheesy masses lying free on the mucosa. At bifurcation there are two irregular spots on the mucosa of trachea one-half inch in diameter, made up of young and caseous tubercles.

*In giving the hour of minimum and maximum temperature when the same occurs more than once the hour of first occurrence is given.

A second focus of disease is found embedded in the left caudal lobe. It consists of a soft caseous mass about one-half inch in diameter without any surrounding recent infiltration and not in direct relation with any air tube.

The most caudal of the posterior mediastinal glands is from six to ten times the normal size and contains upwards of fifty tuberculous foci, from one-eighth to one-half inch in diameter. They are all necrotic but not yet softened. Only one of the bronchial glands contains a focus about three-eighths inch in diameter, which is in the same stage as those in the mediastinal glands.

No. 303.—Holstein cow, 5 years old. Weight, 950 pounds. Calved July, 1892; still giving milk. Pregnant since December 2, 1892. Condition good, but has an occasional hacking cough.

December 7, 1892, 6 a. m.: First injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 102.5° (8 a. m.); after injection, reached in ten hours, 107° (4 p. m.). (For complete record, see p. 59).

February 2, 1893, 9 a. m.: Second injection, 0.25 cc. tuberculin S. From 10 p. m. February 2 to 5 a. m. February 3 the respiration was more or less labored and the cough more frequent. Feces softened, and passed more frequently than usual. Before injection, minimum temperature, 99° (10 a. m.); maximum, 102° (4 p. m.). After injection, minimum temperature, 100.3° (12 a. m.); maximum, reached in eleven hours, 105.6° (8 p. m.). (For complete record see p. 60).

March 18, 1893: Killed for examination.

Autopsy.—Udder: In one of the lymph glands on the right half of the udder four tuberculous foci, varying from one-eighth to one-half inch in diameter. The glands of the left half of the udder contain a number of tuberculous foci, from one-fourth to 1 inch in diameter. All contain a mortar-like substance, with many gritty particles, and appear to be of the same age. The udder itself does not show any disease.

Thorax: The lungs are more or less affected. In the right there are a few nodules in the cephalic lobe; in the caudal lobe a mass as large as a hen's egg, and the entire caudal half involved. In the left lung there is one small nodule in cephalic lobe, three foci fully one-half inch in diameter in the ventral lobe. The caudal lobe is affected very much like its corresponding right lobe. The various foci are situated chiefly along the median dorsal border of the lungs. The contents of the foci are mainly soft, cheesy in character, the individual masses reaching the size of a hen's egg.

Bronchial and posterior mediastinal glands are enlarged and contain caseous foci one-eighth to one-fourth inch in diameter, embedded in a considerable quantity of hyperplastic tissue. The anterior mediastinals contain a few small nodules.

Abdomen: The mesenteric glands are likewise involved. The foci are caseous but still partially firm in texture, and vary from one-eighth to one-half inch in diameter. Small intestine normal.

The glands at the portal fissure are enlarged and contain caseous nodules.

No. 304.—Holstein cow, 5 years old. Weight, 850 pounds. Calved July, 1892, and is giving milk. Pregnant since September 19, 1892. Condition very good.

December 7, 1892: First injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 102.2° (6 p. m.); after injection, 102.6° (6 p. m.). (For complete record see p. 59.)

February 2, 1893, 9 a. m.: Second injection, 0.25 cc. tuberculin S. Before injection, minimum temperature, 98.6° * (9 a. m.); maximum, 102.3° (4 p. m.). After injection, minimum temperature, 101.2° (1 p. m.); maximum, 102.6° (6 p. m.). (For complete record see p. 60.)

April 21, 1893: Killed for examination.

Autopsy.—No tuberculosis.

*The low initial morning temperature in a few cases was probably due to the fact that the cattle were turned into the yard, where they had access to cold water, just before the experiment commenced.

No. 305.—Holstein cow, 5 years old. Weight, 1,000 pounds. Calved October 23, 1892, and is giving milk. Pregnant. Condition good.

February 2, 1893, 9 a. m.: First injection, 0.25 cc. tuberculin S. Before injection, minimum temperature, 99.4° (9 a. m.) maximum; 101.8° (3 p. m.) After injection, minimum temperature, 100.7° (1 p. m.); maximum, 102.8° (5 p. m.). (For complete record see p. 61.)

March 21, 1893, midnight: Second injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 102° (6 p. m.); after injection, reached in sixteen hours, 103° (4 p. m.). (For complete record see p. 69.)

May 25, 1893, midnight: Third injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 101.6° (6 p. m.); after injection, reached in seventeen hours, 103.6° (5 p. m.). (For complete record see p. 74.)

June 29, 1893: Killed for examination.

Autopsy.—No traces of tuberculosis discoverable.

No. 306.—Cow, fifteen-sixteenths Holstein, 6 years old. Weight, 950 pounds. Calved summer of 1892; is giving milk. Pregnant since November 3, 1892.

December 7, 1893, 6 a. m.: First injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 102.6° (8 a. m.); after injection, reached in fourteen hours, 106° (8 p. m.). (For complete record see p. 59.)

February 2, 1893, 9 a. m.: Second injection, 0.25 cc. tuberculin S. Before injection, minimum temperature, 99.6° (10 a. m.); maximum, 102.2° (8 a. m.). After injection, minimum temperature, 100.4° (1 p. m.); maximum, reached in thirteen hours, 106.4° (10 p. m.). (For complete record see p. 61.)

March 21, 1893: Killed for examination.

Autopsy.—Thorax: In the caudal extremity of the left caudal lobe, near the median border and not directly associated with any bronchus, is a tuberculous mass about 1½ inches in diameter. This mass consists of an aggregation of soft cheesy masses, each provided with a connective tissue capsule, and about one-fourth inch in diameter. In the bronchus of this lobe are three or four tuberculous excrescences of the mucosa about three-sixteenths inch in diameter. In the most caudal of the posterior mediastinal glands, which is 5 inches long and 1½ inches wide at widest portion, there are a considerable number of tuberculous foci varying from one-sixteenth to one-half inch in diameter. Several are almost entirely calcareous. The remainder are in a stage indicative of rapid hyperplasia and necrosis. In another gland of the same series near the bifurcation of the trachea, as well as in one of the bronchial glands, there are three or four similar foci.

Abdomen: In many of the mesenteric glands there are minute tubercles with caseous centers, from one to four in a gland, mainly in the cortex. Scattered through the liver tissue chiefly under capsule are small yellowish nodules about one-eighth inch in diameter, probably of parasitic origin.

No. 307.—Cow, half Holstein, 4 years old. Weight, 800 pounds. Calved October 14, 1892, and is giving milk. Pregnant. Condition good.

February 2, 1893: 9 a. m., first injection, 0.25 cc. tuberculin S.; 8 to 9 p. m., marked trembling. Respiration more or less labored. Feces much softened.

Before injection, minimum temperature, 100.8° (4 a. m.); maximum, 102.4° (4 p. m.). After injection, minimum temperature, 101° (1 p. m.); maximum, reached in twelve hours, 107.6° (9 p. m.). (For complete record see p. 61.)

March 21, 1893: Midnight, second injection, 0.5 cc. tuberculin K.

March 22: 7 to 8 p. m., trembling, which becomes very marked about 8 p. m., and then gradually wears off. Feces softened. Before injection, maximum temperature 103° (4 p. m.); after injection, reached in fourteen hours, 106.3° (2 p. m.). For complete record see p. 69.)

April 4, 1893: Killed for examination.

Autopsy.—Thorax: In the most caudal of the posterior mediastinal glands there are about five tuberculous foci ranging from one-fourth to one-half inch in diameter.

They consist of grayish translucent tissue in which is disseminated a network of yellowish lines. One contains a minute calcareous nucleus.

Abdomen: In some mesenteric glands are worm tubercles containing an earth-colored mass.

One of the portal glands contains three tuberculous foci of same character as those in mediastinal gland. The contents are dry and in part calcareous.

No. 308.—Holstein heifer, 2 years old. Weight, 500 pounds. Has never been served by bull. Condition fairly good.

February 2, 1893: 9 a. m., first injection, 0.25 cc. tuberculin S. Before injection, minimum temperature 101° (1 p. m.); maximum, 102.3° (4 p. m.). After injection, minimum temperature 101.1° (12 a. m.); maximum, reached in ten hours, 104.6° (7 p. m.). (For complete record see p. 61.)

March 21, 1893: Midnight, second injection, 0.35 cc. tuberculin K. Before injection, maximum temperature, 102.2° (7 p. m.); after injection, reached in nine hours, 103° (9 a. m.). (For complete record see p. 69.)

May 25, 1893: Midnight, third injection, 0.2 cc. tuberculin S. Before injection, maximum temperature 102.4° (6 p. m.); after injection, reached in eighteen hours, 103° (6 p. m.). (For complete record see p. 74.)

June 5, 1893: Killed for examination.

Autopsy.—The only focus of tuberculosis in this animal is contained in a mediastinal lymphatic gland situated on the dorsal aspect of the trachea at the branching off of the bronchus going to the right cephalic lobe of the lungs. The focus consists of a soft, cheesy, partly gritty mass about one-half inch in diameter. The surrounding tissue is not infiltrated, the gland only slightly enlarged.

No. 309.—Heifer, a mixture of Jersey and Holstein, 2 years old. Weight, 500 pounds. Pregnant since January 22, 1893. Condition fairly good.

February 2, 1893: 9 a. m., first injection, 0.25 cc. tuberculin S.; 6 to 8 p. m., marked trembling, especially violent about 7 p. m. Before injection, minimum temperature 100° (10 a. m.); maximum, 102.4° (5 p. m.). After injection, minimum temperature 101° (12 a. m.); maximum, reached in eleven hours, 104.8° (8 p. m.). (For complete record see p. 62.)

March 21, 1893: Midnight, second injection, 0.35 cc. tuberculin K. Before injection, maximum temperature 102.4° (4 p. m.); after injection reached in sixteen hours, 104° (4 p. m.). (For complete record see p. 69.)

May 25, 1893: Midnight, third injection, 0.2 cc. tuberculin S. Before injection, maximum temperature 102° (8 a. m.); after injection, reached in eighteen hours, 102.6° (6 p. m.). (For complete record see p. 74.)

June 5, 1893: Killed for examination.

Autopsy.—Left retropharyngeal gland enlarged to twice its normal size. On section the parenchyma appears of a more or less uniformly yellowish gray color, and in it are imbedded a considerable number of calcareous particles one-twelfth to one-eighth inch in diameter. The corresponding right gland is larger than normal, but on distinct tubercular changes are detected in it.

No. 310.—Jersey heifer, 18 months old. Weight, 350 pounds. Has never been served by bull. Condition fairly good.

February 2, 1893: 9 a. m., first injection, 0.125 cc. tuberculin S. Before injection, minimum temperature 100° (9 a. m.); maximum, 102.8° (8 a. m.). After injection, minimum temperature, 102° (12 a. m.); maximum, reached in nine hours, 105.8° (6 p. m.). (For complete record see p. 62.)

March 21, 1893: Midnight, second injection, 0.2 cc. tuberculin K. Before injection, maximum temperature 102.6° (4 p. m.); after injection, reached in sixteen hours, 106° (4 p. m.). (For complete record see p. 69.)

April 4, 1893: Killed for examination.

Autopsy.—Thorax: In the most caudal of the posterior mediastinal glands are two tuberculous centers. One is one-half to three-fourths inch in diameter and made up of irregular gritty particles up to one-eighth inch in diameter, embedded in a translucent grayish matrix. The second focus is likewise calcareous. Between the two are pale yellowish necrotic foci about one-eighth inch in diameter, some with a central calcareous particle.

In the gland situated dorsally on the trachea at the root of the bronchus going to right cephalic lobe there are a considerable number of foci varying from one-eighth to one-fourth inch in diameter, the larger calcareous.

No. 311.—Cow, half Holstein, 7 years old. Weight, 850 pounds. Is giving milk. Pregnant since August 24, 1892.

December 7, 1892: 6 a. m., first injection, 0.4 cc. tuberculin K. Before injection, maximum temperature 102.5° (8 a. m.); after injection, reached in twelve hours, 106° (6 p. m.). (For complete record see p. 59.)

March 16, 1893: 9 a. m., second injection, 0.25 cc. tuberculin S.; 9 to 10 p. m., slightly trembling. Before injection, minimum temperature 100° (9 a. m.); maximum, 102.4° (5 p. m.). After injection, minimum temperature, 100.2° (11 a. m.); maximum, reached in fourteen hours, 106.6° (11 p. m.). (For complete record see p. 62.)

March 21, 1893: Killed for examination.

Autopsy.—Thorax: On caudal border of right cephalic lobe, extending inward from free margin for about $1\frac{1}{2}$ inches, is a tuberculous focus 1 inch thick, visible on both lung surfaces and projecting above both surfaces in the collapsed condition of the lung. This focus is situated between the two main branches of the bronchus supplying the lobe. A smaller branch may be traced into it. It consists of a number of small foci up to one-half inch in diameter, made up of soft putty-like cheese, with a central, slightly firmer core, the whole imbedded in fairly firm, not very abundant, connective tissue. Some of the foci are not yet broken down and consist of a yellowish, necrotic center and a grayish, translucent periphery. No calcification is observed. A small segment of the lung tissue on median border of this focus is in a state of tuberculous infiltration of more recent date. The bronchial tubes of this lobe are free from abnormal contents. The mediastinal gland, situated dorsally near right supernumerary bronchus, contains one large focus over one-half inch in diameter, made up of a yellowish, rather soft, cheesy mass. A second focus in the same gland is nearly as large as the first, and contains, in addition to dry, yellowish, cheesy material, a calcareous mass, one-eighth inch in diameter. Besides these, the more or less hyperplastic gland substance contains six or more small necrotic foci.

Abdomen: In the mesenteric glands a few small caseous tubercles are present.

No. 312.—Holstein cow, 6 years old. Weight, 800 pounds. Is giving milk. Pregnant since January 2, 1893.

March 16, 1893: 9 a. m., first injection, 0.25 cc. tuberculin S.; 4:30 p. m., slight trembling, which becomes so violent by 5:30 p. m. that it interferes with counting the pulse. This trembling does not cease entirely until 12 p. m. at 8 p. m. feces considerably softened, each passage followed by straining. Very little of the usual allowance of hay eaten during the evening. Before injection, minimum temperature, 99.8° (10 a. m.); maximum, 103° (4 p. m.). After injection, minimum temperature, 100.4° (11 a. m.); maximum reached in nine hours, 105.2° (6 p. m.). (For complete record see p. 62.)

March 27, 1893, midnight: Second injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 102° (4 p. m.); after injection, reached in eleven hours, 104.8° (11 a. m.). (For complete record see p. 69.)

April 28, 1893: Killed for examination.

Autopsy.—Thorax: In the cephalic lobe of the right lung on the median border is a small focus of disease about 1 inch in diameter. A small bronchus leads to it and

near the focus its mucosa is sprinkled with grayish tubercles. The affected lung tissue contains much connective tissue inclosing calcareous foci. There are very few apparently fresh tubercles.

The posterior mediastinal glands are all affected. The most caudal of the series is considerably enlarged, and contains five dry, largely calcareous foci up to one-half inch in diameter. There is, in addition, in one end of the gland a considerable development of fresh, grayish tubercles; the same is true of the opposite end of the gland. The second gland of the series contains a small, calcareous focus about one-eighth inch in diameter. The third gland, about 1 inch in diameter, contains three or more similar foci. Its exterior is more or less nodulated and retracted. The fourth gland contains two similar foci and some recent infiltration. The fifth is in the same condition as the fourth. The sixth gland contains two similar foci. These glands are moderately enlarged. The bronchial gland, situated on the root of the left bronchus is about $1\frac{1}{2}$ inches in diameter, of slightly irregular outline, and contains in its center a partly calcareous focus one-half inch in diameter and several small foci of more recent origin. The other bronchial glands are also involved.

Abdomen: On the peritoneal aspect of the diaphragm and attached to the reticulum is a tumor about $1\frac{1}{2}$ inches in diameter, containing a small quantity of creamy pus within a dense connective tissue capsule, and surrounded by a considerable quantity of gelatinous-looking connective tissue (traumatism due to foreign body from reticulum).

No. 313.—Cow, fifteen-sixteenths Holstein, 6 years old. Is giving milk. Pregnant since November 25, 1892.

March 16, 1893: 9 a. m., first injection, 0.25 cc. tuberculin S. 9 p. m., periods of slight trembling observed. 10:20 p. m., the trembling is very marked, but ceases by 11 p. m. The long hay not eaten this evening.

March 17, 2 a. m.: Several periods of slight trembling. Before injection, minimum temperature, 99.4° (10 a. m.); maximum, 102.3° (4 p. m.) After injection, minimum temperature, 100.6° (11 a. m.); maximum, reached in fourteen hours, 106.6° (11 p. m.). (For complete record see p. 63.)

March 27, 1893, midnight: Second injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 102.4° (4 p. m.); after injection, reached in thirteen hours, 104.4° (1 p. m.). (For complete record see p. 69.)

April 7, 1893: Killed for examination.

Autopsy.—The only tuberculous lesions found in this animal are two soft masses, about one-half inch in diameter, in the bronchial gland at the root of the left bronchus.

With a small quantity of this caseous material 2 guinea-pigs were inoculated subcutaneously.

One killed two and one-half months after inoculation showed an ulcer at the place of inoculation and the neighboring lymphatics caseous. The spleen and liver contained masses of tubercles, the retrogastric and the bronchial glands were enlarged and necrotic.

The second, killed in a dying condition three months after inoculation, showed very extensive tuberculous changes in liver, spleen, and lungs.

In the cow there is considerable enlargement of all thoracic lymph glands, probably due to traumatic pneumonia, resulting from the passage of a foreign body from the reticulum through the diaphragm.

On the serous aspect of the reticulum there is a patch of gelatinous tissue, about 6 by 8 inches square and from one-half to 1 inch thick, attaching it to diaphragm. The nearest lymph glands of the paunch are enlarged and contain creamy pus. In the thorax the right ventral lobe is enlarged, very firm, and adherent to ribs and diaphragm. A tubular connective tissue passage extends from diaphragm into the affected lobe. The phrenic end is now closed. When this passage was cut a milky pus of penetrating but not offensive odor flowed out from a cavity in the affected

lung tissue about as large as a hen's egg. The firmness of the surrounding lung tissue is due mainly to inflammatory thickening of the interlobular and subpleural tissue. This is most pronounced on the periphery of the cavity, where it forms a thick capsule and decreases gradually from it. The cut surface of the lung tissue presents a marbled appearance in consequence of this condition.

No. 314.—Jersey cow, 6 years old. Weight, 850 pounds. Is giving milk. Pregnant since September 7, 1892.

December 7, 1892, 6 a. m.: First injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 102.5° (4 p. m.); after injection, reached in fourteen hours, 106° (8 p. m.). (For complete record see p. 59.)

March 16, 1893: 9 a. m., second injection, 0.25 cc. tuberculin S. 10:30 p. m., respiration quite short and quick. Very little of the long hay eaten. Feces much softened. Before injection, minimum temperature 99° (9 a. m.); maximum, 102.6° (8 a. m.). After injection, minimum temperature, 100.8° (12 a. m.); maximum, reached in twelve hours, 107° (9 p. m.). (For complete record see p. 63.)

March 18, 1893: Killed for examination.

Autopsy.—Thorax: In the caudal lobe of right lung a triangular mass of tuberculous infiltration about 2 inches in diameter, situated on the cephalic border.

Costal pleura of the left side extending backward from the eighth rib is beset with a small number of isolated and confluent, in part pedicled, tubercles.

In the cephalic lobe of the left lung two tuberculous foci, one about one-half inch in diameter, the other consisting of two nodules, each about one-fourth inch in diameter.

In the caudal lobe of the left lung, near the center, a tuberculous mass of triangular outline, about 4 inches across and 2½ inches thick, tapering toward the lateral border of the lobe.

The tuberculous foci consist of round, encapsuled masses from three-eighths to one-half inch in diameter. The contents, with some exceptions, are still quite firm, not easily disintegrated. Calcareous particles not present. They are surrounded by regions of hyperæmic lung tissue infiltrated with small, partly caseous tubercles or else with lung tissue of nearly normal appearance containing many miliary tubercles. The bronchi leading to the affected regions contain more or less viscid mucus. One leading to a focus more or less softened and broken down contains tubercles on the mucosa.

Bronchial gland at root of left bronchus about 1½ inches in diameter. Contents putty-like, inclosed in a dense capsule in which are embedded small caseous tubercles.

The large posterior mediastinal gland, 4 by 2 by 1½ inches. Parenchyma caseous, as with bronchial gland.

Abdomen: One of portal glands contains a small caseous focus about one-eighth inch in diameter.

A few mesenteric glands contain small, in part caseous, tubercles. Glands not enlarged.

No. 315.—Cow, half Holstein, 6 years old. Weight, 850 pounds. Calved December 2, 1892; is giving milk. Has not been served by bull since calving. Condition good.

March 16, 1893: 9 a. m., first injection, 0.25 cc. tuberculin S. 8 p. m., occasional slight, sharp cough. 9 p. m., pulse quite strong, but the beats are short and sharp. Before injection, minimum temperature, 98.6° (9 a. m.); maximum, 102.4° (5 p. m.). After injection, minimum temperature, 100.8° (12 a. m.); maximum, reached in twelve hours, 106.8° (9 p. m.). (For complete record see p. 63.)

March 27, 1893, midnight: Second injection, 0.4 cc. tuberculin K. Before injection maximum temperature, 102.2° (4 p. m.), after injection, reached in thirteen hours, 105.2° (1 p. m.). (For complete record see p. 70.)

May 25, 1893, midnight: Third injection, 0.5 cc. tuberculin S. Before injection, maximum temperature 103.1° (8 p. m.); after injection, reached in twelve hours, 105.3° (12 a. m.). (For complete record see p. —.)

June 1, 1893: Killed for examination.

Autopsy.—Right parotid lymph gland contains several tuberculous foci with cheesy contents embedded in a mass of firm connective tissue. These foci are each about one-fourth inch in diameter. Both retro-pharyngeal glands are enlarged, about 2 by 1 by $\frac{1}{4}$ inch in size, quite nodular in form. On section both glands are almost completely converted into a mass of confluent tuberculous foci. Each focus is about one-fourth inch in diameter, with soft center of putty-like consistency and a rather firm connective tissue capsule. The disease in both glands is equally extensive and of about the same age. Both tonsils are enlarged and contain tuberculous foci. These appear as slightly elevated patches on the cut surface, firmer than the gland tissue and showing within their mass a network of small yellowish (necrotic) lines.

No. 316.—Jersey cow, 6 years old. Is giving milk. Pregnant since September 25, 1892.

March 16, 1893, 9 a. m.: First injection, 0.25 cc. tuberculin S. Before injection, minimum temperature, 100.8° (12 p. m.); maximum, 102.6° (4 p. m.). After injection, minimum temperature, 100.6° (11 a. m.); maximum, reached in fourteen hours, 106.2° (11 p. m.). (For complete record see p. 63.)

March 27, 1893, midnight: Second injection, 0.4 cc. tuberculin K.

March 28, 9 to 10 a. m.: Stands with back very much arched and trembles quite violently. Before injection, maximum temperature, 103.1° (4 p. m.); after injection, reached in twelve hours, 106° (12 a. m.). (For complete record see p. 70.)

April 7, 1893: Killed for examination.

Autopsy.—Thorax: A considerable number of tuberculous nodules in the large posterior mediastinal gland, and in the mediastinal near arch of aorta. About a dozen yellowish nodules, one-sixteenth inch in diameter, in the bronchial gland at root of left bronchus.

Abdomen: One small, doubtful nodule in a mesenteric gland.

No. 317.—Heifer, fifteen-sixteenths Holstein, 3 years old. Weight, 500 pounds. Reported to have been served by bull every three weeks during the past six months without becoming pregnant.

March 16, 1893: 9 a. m., first injection, 0.25 cc. tuberculin S. 8 p. m., trembling, which becomes very violent at 9 p. m., and ceases about 11 p. m. Before injection, minimum temperature, 100° (10 a. m.); maximum, 103° (5 p. m.). After injection, minimum temperature, 101.4° (12 a. m.); maximum, reached in eighteen hours, 105.8° (3 p. m.). (For complete record see p. 64.)

March 27, 1893, midnight: Second injection, 0.3 cc. tuberculin K. Before injection, maximum temperature, 102.8° (5 p. m.); after injection, 102.7° (1 p. m.). (For complete record see p. 70.)

April 21, 1893: Killed for examination.

Autopsy.—The only lesion of tuberculous nature in this animal is found in the bronchial gland at the root of the left bronchus. This gland is enlarged and contains about six foci, some of which are about one-half inch in diameter. All are caseous and a few contain a considerable number of calcareous particles.

In both kidneys the external surface is sprinkled over with small grayish spots up to one-twelfth inch in diameter. These correspond to streaks of the same color penetrating the cortex radially for a depth of one-eighteenth to one-sixth inch. Organs otherwise normal.

No. 318.—Heifer, fifteen-sixteenths Holstein, 1 year old. Weight, 500 pounds. March 16, 1893: 9 a. m., first injection, 0.25 cc. tuberculin S. 6:30 to 7 p. m., occasional periods of trembling. Hay only partly eaten. Before injection, minimum

temperature, 98.6° (10 a. m.); maximum, 103.2° (8 a. m.). After injection, minimum temperature 101.4° (12 a. m.); maximum, reached in ten hours, 107.4° (7 p. m.). (For complete record see p. 64.)

March 27, 1893: The temperature was taken for another injection, but owing to a rise from 102° at 8 p. m. to 105° at 11 p. m., due to an unknown cause, the injection was postponed.

March 28: The temperature was 104.8° at 7 a. m., 103.5° at 8 a. m., and 102° at 9 a. m., after which it continued normal. Excepting the elevation in temperature the animal was apparently in good health. (See also No. 357.)

April 12, 1893, midnight: Second injection, 0.2 cc. tuberculin S.

April 13, 9:20 a. m.: Periods of slight trembling. Before injection, maximum temperature, 103.4° (5 p. m.); after injection, reached in seventeen hours, 107.2° (5 p. m.). (For complete record see p. 70.)

April 14, 1893: Killed for examination.

Autopsy.—Thorax: In the right caudal lobe a tuberculous region about 4 inches long and 2 inches in diameter. This consists almost entirely of soft caseous masses embedded in a conglomerate of rather thin-walled, connective-tissue capsules. Only on the periphery the lung tissue is still recognizable as such. The surrounding lung tissue is free from recent infiltration. Trachea and bronchus of affected lobe free from tuberculous changes. Some cheesy masses found, in which tubercle bacilli were searched for with negative result. Posterior mediastinal glands consolidated into a mass 8 to 10 inches long and 3 inches in diameter at the center. This glandular mass is found on section to be grayish yellow in color and penetrated by a dense network of yellowish lines. The bronchial glands are free with one exception. This contains a single yellowish, caseous focus.

Abdomen: One of the mesenteric glands contains a single recent focus about one-eighth inch in diameter.

In one of the portal glands two gritty foci one-eighth and one-fourth inch in diameter.

No. 319.—Heifer, fifteen-sixteenths Holstein, 1 year old. Weight, 500 pounds. Has never been served by bull.

March 16, 1893, 9 a. m.: First injection, 0.25 cc. tuberculin S. Before injection, minimum temperature, 99° (11 a. m.); maximum, 103.3° (5 p. m.). After injection, minimum temperature 100.8° (12 a. m.); maximum, 102.8° (9 p. m.). (For complete record see p. 64.)

March 27, 1893, midnight: Second injection, 0.2 cc. tuberculin K. Before injection, maximum temperature, 103° (6 p. m.); after injection, 103° (7 p. m.). (For complete record see p. 70.)

May 25, 1893, midnight: Third injection, 0.2 cc. tuberculin S. Before injection, maximum temperature, 103.6° (6 p. m.); after injection, 102.9° (6 p. m.). (For complete record see p. 74.)

July 3, 1893: Killed for examination.

Autopsy.—In the left bronchial gland there are three small tuberculous foci largely calcareous. Recent surrounding infiltration absent. Slight adhesions of cephalic end of liver to surrounding structures.

No. 520.—Heifer, mixture of Jersey and Holstein, 2½ years old. Weight, 700 pounds. Pregnant since February 15, 1893. Previous to this she had been served by the bull every three weeks for five or six months without conceiving.

March 16, 1893, 9 a. m.: First injection, 0.25 cc. tuberculin S. Before injection, minimum temperature, 98.8° (9 a. m.); maximum, 102.6° (5 p. m.); after injection, minimum temperature, 99.8° (12 a. m.); maximum, reached in fourteen hours, 104.2° (11 p. m.). (For complete record see p. 64.)

March 27, 1893, midnight: Second injection, 0.3 cc. tuberculin K. Before injection, maximum temperature, 102.8° (4 p. m.); after injection, 102.6° (1 p. m.). (For complete record see p. 70.)

May 25, 1893, midnight: Third injection, 0.2 cc. tuberculin S. Before injection, maximum temperature, 102° (6 p. m.); after injection, reached in seventeen hours, 103.4° (5 p. m.). (For complete record see p. 74.)

June 15, 1893: Killed for examination.

Autopsy negative.

No. 321.—Jersey heifer, 3 years old. Pregnant since September 19, 1892.

March 16, 1893, 9 a. m.: First injection, 0.25 cc. tuberculin S. Before injection, minimum temperature, 100.4° (12 a. m.); maximum, 102.2° (6 p. m.). After injection, minimum temperature, 100.8° (1 p. m.); maximum, reached in fourteen hours, 103.4° (11 p. m.). (For complete record see p. 65.)

March 27, 1893, midnight: Second injection, 0.3 cc. tuberculin K. Before injection, maximum temperature, 102.5° (6 p. m.); after injection, 102° (5 p. m.). (For complete record see p. 70.)

May 25, 1893, midnight: Third injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102° (6 p. m.); after injection, reached in eighteen hours, 102.7° (6 p. m.). (For complete record see p. 74.)

June 29, 1893: Killed for examination.

Autopsy.—Traces of tuberculosis not discoverable. Slight adhesions of cephalic end of liver to diaphragm. In this region on the free border a yellowish mass of liver tissue about one-half inch in diameter. The color is due to more or less complete fatty metamorphosis of the liver cells.

No. 322.—Jersey heifer, 1 year old. Weight, 450 pounds. Has never been served by bull.

March 16, 1893, 9 a. m.: First injection, 0.2 cc. tuberculin S. Before injection, minimum temperature, 99.6° (9 a. m.); maximum, 102.5° (9 p. m.). After injection, minimum temperature, 99° (12 a. m.); maximum, reached in fourteen hours, 103° (11 p. m.). (For complete record see p. 65.)

March 27, 1893, midnight: Second injection, 0.2 cc. tuberculin K. Before injection, maximum temperature, 102.8° (5 p. m.); after injection, reached in thirteen hours, 104.2° (1 p. m.). (For complete record see p. 70.)

May 25, 1893, midnight: Third injection, 0.125 cc. tuberculin S. Before injection, maximum temperature, 102.2° (6 p. m.); after injection, 102.8° (5 p. m.). (For complete record see p. 74.)

July 3, 1893: Killed for examination.

Autopsy.—In the large mediastinal gland there is one tuberculous focus situated near the cephalic end of the gland. It is about one-half inch in diameter and almost completely calcareous. The surrounding tissue is free from recent infiltration.

No. 323.—Heifer, half Holstein, $2\frac{1}{2}$ years old. Weight, 750 pounds. Pregnant since September 26, 1892.

March 16, 1893, 9 a. m.: First injection, 0.25 cc. tuberculin S. Before injection, minimum temperature, 99.7° (9 a. m.); maximum, 103.5° (5 p. m.); after injection, minimum temperature, 100.4° (11 a. m.); maximum, reached in fourteen hours, 106.4° (11 p. m.). (For complete record see p. 65.)

March 27, 1893, midnight: Second injection, 0.3 cc. tuberculin K. Before injection, maximum temperature, 103.4° (5 p. m.); after injection, reached in thirteen hours, 105.2° (1 p. m.). For complete record see p. 70.)

April 12, 1893: Killed for examination.

Autopsy.—In this animal the thoracic lymphatics only are involved. One bronchial gland measures 2 by 1 inch and is completely converted into a soft caseous mass. Similarly, three out of four of the chain of posterior mediastinal glands are as large as hens' eggs and completely caseous. Calcification absent.

No. 324.—Heifer, fifteen-sixteenths Holstein, 3 years old. Weight, 800 pounds. Pregnant since June 16, 1892.

March 16, 1893, 9 a. m.: First injection, 0.25 cc. tuberculin S. Has not eaten anything during the evening or night. Before injection, minimum temperature, 100.5° (10 a. m.); maximum, 104° (5 p. m.); after injection, minimum temperature, 102.5° (12 a. m.); maximum, reached in eighteen hours, 105.8° (3 a. m.). (For complete record see p. 65.)

March 17: Gave birth to a dead calf, followed by partial retention of the after-birth.

May 27, 1893, midnight: Second injection, 0.3 cc. tuberculin K.

March 28, 7 to 8 a. m.: Periods of marked trembling. Before injection, maximum temperature, 102.8° (5 p. m.); after injection, reached in ten hours, 107° (10 a. m.). (For complete record see p. 70.)

April 12, 1893: Killed for examination.

Autopsy.—Thorax: The cephalic lobe of the right lung (cephalic half) is almost entirely involved in tuberculosis. Only a little tissue at the root of the bronchus and a few areas of the tip still air-containing. The lesion is an intermingling of soft caseous foci with surrounding, more recently infiltrated, lung tissue. The lobe appears as if made up of lumps of various sizes, owing to its collapsed state and the large size of the tuberculous masses. The bronchial mucosa is beset with a layer of recent tubercle eruptions near its root, and farther along yellowish flakes are found mingled with mucus.

The bronchial glands are all enlarged, the infiltrated parenchyma more or less caseous and containing gritty particles. One of these is as large as a goose egg and contains a number of rather small cheesy nodules.

The posterior mediastinal glands likewise contain caseous foci. The process appears less extensive here than in the bronchial.

Abdomen: One of the portal glands contains a tuberculous mass about one-half inch in diameter. This is still firm, yellowish, necrotic, and is surrounded by a thick capsule. The center contains calcareous particles.

On the convex surface of the liver is a flattish tuberculous mass about three-fourths inch square, elevated above the liver surface about one-eighth inch. On section it is found one-half inch thick, dipping beneath the surface of the liver; the center soft, caseous; the periphery firm, grayish translucent.

No. 325.—Grade Holstein cow, 6 years old. Weight, 850 pounds. Calved March 1, 1893, and has not been served by bull since; is giving milk.

March 21, 1893, midnight: First injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 102° (7 p. m.); after injection, 102° (5 p. m.). (For complete record see p. 66.)

May 25, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.8° (6 p. m.); after injection, 103° (5 p. m.). (For complete record see p. 70.)

Not killed.

No. 326.—Grade Holstein cow, 6 years old. Weight, 900 pounds. Calved February 14, 1893, and has not been served by bull since; is giving milk.

March 21, 1893, midnight: First injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 102.2° (8 a. m.); after injection, 102.8° (4 p. m.). (For complete record see p. 66.)

May 25, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 103° (8 p. m.); after injection, 103.4° (3 p. m.). (For complete record see p. 70.)

Not killed.

No. 327.—Cow, 7 years old. Weight, 950 pounds. Calved during spring of 1892 and is still giving milk. Supposed to be pregnant since December 9, 1892.

March 21, 1893, midnight: First injection, 0.4 cc. tuberculin K.

March 22, 9 a. m.: Feces semifluid, very much thinner than usual. Before injection, maximum temperature, 103.2° (8 a. m.); after injection, 103.4° (4 p. m.). (For complete record see p. 66.)

May 25, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102° (4 p. m.); after injection, reached in fourteen hours, 103.6° (2 p. m.). (For complete record see p. 71.)

Not killed.

No. 328.—Cow, fifteen-sixteenths Holstein, 4 years old. Weight, 900 pounds. Calved December 29, 1892, and is giving milk. Pregnant.

March 21, 1893, midnight: First injection, 0.4 cc. tuberculin K.

March 22, 9:30 to 10 a. m.: Occasional periods of slight trembling. Before injection, maximum temperature, 102° (7 p. m.); after injection, reached in twelve hours, 104.2° (12 a. m.). (For complete record see p. 66.)

April 12, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.7° (4 p. m.); after injection, reached in sixteen hours, 105.4° (4 p. m.). (For complete record see p. 71.)

May 12, 1893: Killed for examination.

Autopsy.—In one tonsil an abscess about one-half inch in diameter, the contained pus like starch paste in appearance.

The tuberculous lesions were limited to the large posterior mediastinal gland. This is 5 by $\frac{1}{2}$ by $1\frac{1}{2}$ inches in size. Near one end there are 5 dry, mortar-like masses one-fourth to one-half inch in size inclosed in thin-walled capsules. No recent infiltration in the surrounding gland tissue.

No. 329.—Cow, fifteen-sixteenths Holstein, 3 years old. Weight, 700 pounds. Calved February 1, 1893, and has not been served by the bull since; is giving milk.

March 21, 1893, midnight: First injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 103° (6 p. m.); after injection, reached in nine hours, 107.5° (9 a. m.). (For complete record see p. 66.)

April 12, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature 103.4° (4 p. m.); after injection, reached in ten hours, 105.8° (10 a. m.). (For complete record see p. 71.)

April 28, 1893: Killed for examination.

Autopsy.—In this animal the tuberculous lesions are limited to the retropharyngeal glands.

The right is as large as a small fist. The parenchyma has undergone diffuse necrosis. In the external layer of gland tissue are embedded a number of minute caseous tubercles.

The other gland is 4 by 1 by $1\frac{1}{2}$ inches in size. It feels as if made up of a large number of lumps. On section the foci are caseous and embedded in more or less connective tissue. There is also some diffuse necrosis of the parenchyma.

No. 330.—Cow, 12 years old. Weight, 900 pounds. Calved October 14, 1892, and has not been served by bull since; is giving milk.

March 21, 1893, midnight: First injection, 0.4 cc. tuberculin K.

March 22, 9:30 to 10:30 a. m.: Very marked trembling. Feces somewhat softened and passed more frequently than usual. Before injection, maximum temperature, 102.2° (7 p. m.); after injection, reached in twelve hours, 105.8° (12 a. m.). (For complete record see p. 66.)

April 12, 1893, midnight: Second injection, 0.25 cc. tuberculin S.

April 13, 8:40 a. m.: Frequent periods of marked trembling. Before injection, maximum temperature, 102° (8 a. m.); after injection, reached in eleven hours, 105.2° (11 a. m.). (For complete record see p. 71.)

April 25, 1893: Killed for examination.

Autopsy.—The only tuberculous lesion discoverable in this case was found in the gland at the root of the left bronchus, as a small yellowish focus about one-eighth

inch in diameter. In sections of hardened tissue it appears separated from the remainder of the gland by a thin connective tissue capsule. The central portion is necrotic, the peripheral portion made up largely of granulation tissue in which giant cells are quite sparsely disseminated. Tubercle bacilli were not detected.

No. 331.—Holstein cow, 6 years old. Weight, 850 pounds. Calved January, 1892; is giving milk. Pregnant since September 22, 1892.

March 21, 1893, midnight: First injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 102° (6 p. m.); after injection, reached in seventeen hours, 106.2° (5 p. m.). (For complete record see p. 66.)

April 12, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 101.8° (8 a. m.); after injection, reached in eighteen hours, 105.8° (6 p. m.). (For complete record see p. 71.)

April 18, 1893: Killed for examination.

Autopsy.—The only tuberculous lesion in this case is represented by a caseous focus about one-half inch in diameter, embedded in the caudal lobe of the left lung near median border. This focus is adjacent to a small bronchus and is associated with a tuberculous mass as large as a hemp seed. Scrapings from the inner wall of the capsule inclosing the caseous mass negative as regards tubercle bacilli.

A guinea pig inoculated subcutaneously with some of the caseous mass died three months later. The autopsy showed extensive tuberculous changes in the liver and spleen and isolated caseous masses in the lungs.

No. 332.—Holstein cow, 7 years old. Calved spring of 1892 and is still giving milk. Pregnant since August 27, 1892.

March 21, 1893, midnight: First injection, 0.4 cc. tuberculin K.

March 22, 10 a. m.: Feces slightly softened. Before injection, maximum temperature, 102.4° (3 p. m.); after injection, reached in twelve hours, 107.1° (12 a. m.). (For complete record see p. 66.)

April 12, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.8° (4 p. m.); after injection, reached in eighteen hours, 106.2° (6 p. m.). (For complete record see p. 71.)

April 14, 1893: Killed for examination.

Autopsy.—The tuberculous lesions in this case were limited to one of the smaller posterior mediastinal glands. A portion of this gland on section had a pale grayish appearance, which on closer examination and especially after a short sojourn in alcohol, appeared made up of very minute tubercles.

Sections of this region after hardening in alcohol were carefully examined. The suspicious focus was shown to consist of an aggregation of tubercles, each provided with one or more giant cells. In many of these from 1 to 3 tubercle bacilli could be demonstrated by Gabbett's stain.

There is evidence of former inflammation of the serous membranes of thorax in slight but firm adhesion of various lobes of the lungs to each other, to the diaphragm and the pericardium.

No. 333.—Jersey cow, 5 years old. Weight, 600 pounds. Calved, December 20, 1892, and has not been served by bull since; is giving milk.

March 21, 1893, midnight: First injection, 0.3 cc. tuberculin K.

March 22, 9 a. m.: Feces semifluid, much thinner than usual. Before injection, maximum temperature, 102° (7 p. m.); after injection, reached in nine hours, 106.9° (9 a. m.). (For complete record see p. 66.)

April 12, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.4° (8 a. m.); after injection, reached in thirteen hours, 105.6° (1 p. m.). (For complete record see p. 71.)

April 18, 1893: Killed for examination.

Autopsy.—In this animal the tuberculous infection is limited to the abdominal cavity.

Mesenteric glands: Two are involved. One contains three foci, each about one-eighth inch in diameter, two caseous and one calcareous. The other contains a partly caseous, partly calcareous, focus three-eighths inch in diameter, and one one-eighth inch in diameter. Several glands contain worm tubercles.

Liver: Two portal glands are moderately enlarged. One contains three firm, dry, caseous foci, the other contains two quite small yellowish foci.

In the large posterior lobe of the liver are two contiguous tuberculous foci embedded in the liver tissue and reaching the convex surface. One of these is fully 3 inches long and 2 inches thick. The other is about 1 inch in diameter. They are both made up of an abundance of dense connective tissue inclosing a large number of small, partly caseous foci, some of which are one-fourth inch in diameter. The diaphragm is adherent to the liver over these foci.

In the region of the second stomach, between it and the diaphragm, there are firm adhesions occasioned by traumatic inflammation and suppuration. When the adhesions are severed, several masses of firm, almost cartilaginous tissue (indurated glands) (?) are found in this adherent area surrounded by more or less gelatinous infiltration. The firm masses are softened centrally (abscesses).

No. 334.—Holstein cow, 3 years old. Weight, 1,000 pounds. Calved September, 1892; is giving milk. Pregnant since February 6, 1893.

March 21, 1893, midnight: First injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 102.4° (3 p. m.); after injection, reached in fifteen hours, 102.9° (3 p. m.). (For complete record see p. 66.)

April 12, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 101.8° (9 a. m.); after injection, reached in seventeen hours, 102.5° (5 p. m.). (For complete record see p. 71.)

May 25, 1893, midnight: Third injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.2° (6 p. m.); after injection, reached in seventeen hours, 102.7° (5 p. m.). (For complete record see p. 74.)

July 6, 1893: Killed for examination.

Autopsy.—In the left bronchial gland a soft, caseous focus about one-half inch in diameter situated in the center of the gland. In the mediastinal gland near it, resting loosely on the root of the left bronchus, a similar focus. (Unfortunately the thoracic glands, removed for further examination in the laboratory, were rejected through some inadvertence. The remaining glands were of normal size, and if tuberculous the foci must have been quite small.)

No. 335.—Jersey cow, 5 years old. Weight, 700 pounds. Calved January 28, 1893, and has not been served by bull since; is giving milk.

March 21, 1893, midnight: First injection, 0.4 cc. tuberculin K.

March 22, 9:30 to 10:30 a. m.: Marked trembling. Before injection, maximum temperature, 102.2° (8 p. m.); after injection, reached in seventeen hours, 107.8° (5 p. m.). (For complete record see p. 66.)

April 12, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102° (4 p. m.), after injection, reached in twelve hours, 105.2° (12 a. m.) (For complete record see p. 71.)

April 25, 1893: Killed for examination.

Autopsy.—Left retropharyngeal gland is about 3½ inches long and 1 to 1½ inches thick, more or less nodular or lobulated. It contains an aggregation of soft, caseous foci from one-fourth to one-half inch in diameter. Foci in periphery of gland smaller and firmer than those centrally situated.

Thorax: The large posterior mediastinal gland contains two small firm caseous foci; the contiguous gland contains about ten foci one-eighth to three-sixteenths inch in diameter.

Of the bronchial glands the small one near the root of right main bronchus contains a firm caseous mass equal to one-half the bulk of the gland.

Abdomen: In one of the portal glands two firm, caseous masses about three-eighths inch in diameter. The liver tissue contains a few subcapsular nodules of parasitic origin.

No. 336.—Jersey cow, 8 years old. Weight, 800 pounds. Calved in spring of 1892, and is still giving milk. Not pregnant, and has not been served by bull since July 25, 1892.

March 21, 1893, midnight: First injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 102.6° (7 p. m.); after injection, reached in seventeen hours, 106° (5 p. m.). (For complete record see p. 66.)

April 12, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.8° (5 p. m.); after injection, reached in seventeen hours, 104.9° (5 p. m.). (For complete record see p. 71.)

May 25, 1893, midnight: Third injection, 0.35 cc. tuberculin S. Before injection, maximum temperature, 102.9° (6 p. m.); after injection, reached in twenty hours, 103.8° (8 p. m.). For complete record see p. 74.)

June 1, 1893: Killed for examination.

Autopsy.—Thorax: In the caudal lobe of right lung near the caudal extremity and about 3 inches from lateral border are three tuberculous foci in the lung tissue. One of these is situated on the periphery of a small bronchus and is about one-half inch in diameter, one section yellowish, the center broken down into a soft pus-like mass. The second focus is near the first, embedded in a lobule. Softening not yet begun. The third focus is nearer the first and is like second, but somewhat smaller. Near these on ventral surface of the lungs and directly under the same bronchus is a subpleural tuberculous mass resembling the second and third described. Slight yellowish mass in bronchus near these foci. The large posterior mediastinal gland is about 4 inches long and 1 to 1½ inches thick. On section fully one-half of the gland, especially the cortex, is involved and appears as a grayish mass in which there is an abundant network of yellowish lines and patches. Only one of the other mediastinal glands shows distinct tuberculous infection. In caudal portion is contained a tuberculous mass about one-half by one-fourth inch in diameter, which is in the same condition as gland just described. The bronchial glands are free from infection and quite markedly pigmented.

Abdomen: One of the mesenteric glands contains a tuberculous mass 1 by ½ by 1 by ¼ inches in size. On section this mass is oval in outline, sharply defined, firm. It consists of a close network of yellowish lines and patches, among which only a little grayish tissue is still visible. The process here seems slightly more advanced toward necrosis than in the thorax. Some worm nodules are also present in the mesenteric glands.

No. 337.—Cow, 12 years old. Weight, 950 pounds. Calved in spring of 1892, still giving milk. Pregnant since September 15, 1892.

March 21, 1893, midnight: First injection, 0.4 cc. tuberculin K.

March 22, 10 a. m.: Periods of slight trembling. Before injection, maximum temperature, 102.6° (8 p. m.); after injection, reached in fourteen hours, 105.5° (2 p. m.). (For complete record see p. 67.)

April 12, 1893, midnight: Second injection, 0.25 cc. tuberculin S.

April 13, 10 to 10:30 a. m.: Occasional periods of slight trembling. Before injection, maximum temperature, 102° (8 p. m.); after injection, reached in nineteen hours, 105° (7 p. m.). (For complete record see p. 71.)

April 14, 1893: Killed for examination.

Autopsy.—A soft caseous mass in one of the retropharyngeal glands one-half inch in diameter.

Thorax: In the principal lobe of the right lung a large tuberculous focus resembling closely that of No. 318 both as to the condition of the contents and the absence of any surrounding infiltration. The small air tube leading to it is occluded with yellowish cheesy material. Tubercle bacilli not detected in it.

One of the posterior mediastinal glands contains 4 caseous foci from one-fourth to one-half inch in diameter. The bronchial gland at root of left bronchus contains four quite small yellowish foci.

Abdomen: Mesenteric glands involved. A considerable number contain foci varying from one-eighth to one-fourth inch in diameter. They are very firm to the touch and project above the surface of the gland as round yellow bodies. The glands are not enlarged. The tubercular foci are all firm, necrotic, some largely calcareous. Besides the tuberculous changes, worm nodules are not uncommon.

No. 338.—Jersey cow, 3 years old. Weight, 500 pounds. Calved January 28, 1892. Condition, very thin. Shows symptoms of advanced tuberculosis, and has been isolated from herd for from fifteen to eighteen months.

March 27, 1893, midnight: Injected 0.3 cc. tuberculin K. Before injection, maximum temperature, 103.6° (2 p. m.); after injection, reached in seven hours, 103.8° (7 a. m.) (For complete record see p. 67.)

April 4, 1893: Killed for examination.

Autopsy.—Case of advanced tuberculosis. Retropharyngeal glands, tonsils, larynx, trachea, bronchi, lungs, thoracic glands, and the pleura extensively diseased. In the abdomen the various groups of lymphatics greatly enlarged and tuberculous. The omentum and serosa of stomachs are beset with patches of confluent tubercles.

All Peyer's patches of the small intestine are extensively infiltrated with tubercles and the mucosa ulcerated. The spleen, liver, and kidneys (excepting the serous coverings) are free from tuberculous changes recognizable with the unaided eye. The udder and pubic glands are likewise free from infection.

No. 339.—Cow, fifteen-sixteenths Holstein, 7 years old. Weight, 1,000 pounds. Calved summer of 1892, and is still giving milk. Pregnant since December 13, 1892.

March 27, 1893, midnight: First injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 102° (5 p. m.); after injection, reached in eleven hours, 103.6° (11 a. m.). (For complete record see p. 67.)

May 1, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 103° (5 p. m.); after injection, reached in nineteen hours, 103.5° (7 p. m.). (For complete record see p. 71.)

May 25, 1893, midnight: Third injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 103° (6 p. m.); after injection, 102.6° (5 p. m.). (For complete record see p. 74.)

June 19, 1893: Killed for examination.

Autopsy.—Thorax: In the lungs there are not less than 8 isolated tuberculous foci. Five of these are in the right caudal, 2 in the left caudal, and 1 in the right cephalic lobe. In the right caudal lobe 3 foci are situated along the dorsomedian region (i. e., in that portion of the lung tissue resting against the sides of the vertebra and the dorsal end of the ribs). They are situated above (or dorsal of) the main bronchus, excepting the most caudal of the 3 which surrounds the bronchus. These foci are visible on the lung surface. They vary in size, the smallest being three-fourths inch in diameter, the largest 2 or $2\frac{1}{2}$ inches in diameter. They consist in the main of aggregations of cysts containing very soft, cheesy masses, inclosed in thin-walled capsules. These cysts vary in diameter from one-eighth to three-fourths inch. The focus nearest the root of the lobe is made up of several such cysts and a considerable mass of lung tissue which appears to consist of a large number of small cheesy foci. The peculiar yellowish mottled appearance of this tissue from the pleural surface and a careful inspection of the cut surface suggests aspiration of cheesy matter resulting in caseous broncho-pneumonia. The main bronchus, moreover, contains some loose cheesy masses. This lobe contains, in addition to these 3 foci, 2 small embedded ones situated near the lateral margin of the lobe, of which 1 is cheesy, the other firm, grayish in color.

In the left caudal lobe there are 2 foci. One in the dorsomedian region under the pleura, about three-fourths inch in diameter, consists of a soft central mass surrounded

by an aggregation of small cheesy masses. The other is about 1 inch in diameter and is made up entirely of soft cheesy foci.

On the caudal margin of the second cephalic lobe there is a small triangular region of very thin collapsed tissue in which are situated 3 small masses, consisting of a dense, grayish tissue inclosing a yellow cheesy nucleus.

Thoracic lymph glands: Large posterior mediastinal gland contains near the caudal end a dry, cheesy, partially gritty focus measuring one-half by one-fourth inch. In the same region there are 2 cheesy foci about three-sixteenths inch in diameter. Toward the middle there are 2 minute yellowish foci one-sixteenth inch in diameter. In mediastinal gland, situated on the œsophagus at the level of the bifurcation of the trachea, there is 1 small tubercle, with cheesy, yellowish center, about one-sixteenth inch in diameter. In bronchial gland at root of left bronchus there are 2 small foci, one-sixteenth and one-eighth inch in diameter, of a grayish color and yellowish center. In the gland at root of right supernumerary bronchus there is a focus one-fourth inch in diameter, with yellowish, cheesy contents embedded in a firm, grayish capsule, and a second smaller focus composed almost entirely of firm, grayish tissue, with a minute yellowish center.

In 3 of the mesenteric glands there are several isolated tubercles, quite small, having a yellowish color. One gland also contains an aggregation of such tubercles.

No. 340.—Cow, fifteen-sixteenths Holstein, 9 years old. Weight, 1,100 pounds. Calved summer of 1892; is still giving milk. Pregnant since January 13, 1893.

March 27, 1893, midnight: First injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 101.6° (4 p. m.); after injection, reached in ten hours, 104° (10 p. m.). (For complete record see p. 67.)

May 1, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.2° (4 p. m.); after injection, reached in fifteen hours, 102.6° (3 p. m.). For complete record see p. 72.)

May 23, 1893: Killed for examination.

Autopsy.—In this case tuberculous lesions could not be found. In the uterus a fetus about 3 months old, dead and beginning to disintegrate. Free from odor.

No. 341.—Half Holstein cow, 9 years old. Weight, 900 pounds. Calved spring of 1892; still giving milk. Not pregnant, and has not been served by bull since June 24, 1892.

March 27, 1893, midnight: First injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 103° (9 p. m.); after injection, reached in eleven hours, 105° (11 a. m.). For complete record see p. 67.)

May 1, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 103.4° (6 p. m.); after injection, reached in twelve hours, 106° (12 a. m.). (For complete record see p. 72.)

May 19, 1893: Killed for examination.

Autopsy.—Lungs: In the right caudal lobe beneath the pleura of the dorsal surface there is a tuberculous focus about 1½ inches in diameter, not directly connected with any traceable branch of the bronchus. This focus is made up of lobules in different stages of caseation. In one lobe the cheese is very soft and easily removed. In others it is slightly firmer, but likewise removable without difficulty. The lung tissue surrounding this focus for a distance of one-half to 1 inch contains a considerable number of minute grayish tubercles. In the trachea, near the bifurcation, there are several small masses of cheesy matter lying loose on the mucous membrane. There are also 2 tuberculous patches on the mucosa, 1 at the place of bifurcation, the other about 1 inch from it, both made up of fresh tubercles mingled with the tubercular ulcers, which have elevated margins undermined with cheesy deposits. These ulcers are about one-fourth inch in diameter.

Thoracic glands: In the gland at root of left bronchus there are 5 or 6 small grayish tubercles, a few with minute yellowish centers. In the caudal mediastinal

gland, near its middle portion, there is one completely calcified focus about one-fourth inch in diameter, and several small translucent tubercles about one-sixteenth inch in diameter, all situated in the cortex. In middle of the same gland there is a constricted, retracted portion containing a few tubercles. In an adjacent portion also a few barely recognizable grayish tubercles. In another portion of cortex a small patch of recent infiltration.

No. 342.—Cow, fifteen-sixteenths Holstein, 9 years old. Weight, 900 pounds. Calved December 14, 1892, and has not been served by bull since; is giving milk.

March 27, 1893, midnight: First injection, 0.4 cc. tuberculin K.

March 28, 8:30 a. m.: Trembling quite marked and stands with back slightly arched. Before injection, maximum temperature, 102.2° (5 p. m.); after injection, reached in twelve hours, 106° (12 a. m.). (For complete record see p. 67.)

May 1, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 103.4° (5 p. m.); after injection, reached in nineteen hours, 104.2° (7 p. m.). (For complete record see p. 72.)

May 19, 1893: Killed for examination.

Autopsy.—Thorax: In gland at root of left bronchus half a dozen tuberculous foci one-sixteenth to one-fourth inch in diameter, caseous and still firm. In the cephalic end of the large mediastinal gland one small similar focus. Traumatic inflammation of walls of second stomach owing to presence of wire 4 inches long.

(Owing to some mistake the affected glands were not taken to the laboratory for reexamination. Hence the notes are somewhat incomplete.)

No. 343.—Cow, fifteen-sixteenths Holstein, 6 years old. Weight, 1,100 pounds. Calved during summer of 1892; still giving milk. Served by bull January 11, 1893, but is not pregnant.

March 27, 1893, midnight: First injection, 0.4 cc. tuberculin K.

March 28; 7:30 a. m., respiration accelerated; pulse, 80. Slight trembling with twitching of muscles, especially in the gluteal region. The back is slightly arched; 11 a. m., feces considerably softened. Before injection, maximum temperature, 101.6° (4 p. m.); after injection, reached in ten hours, 107° (10 a. m.). (For complete record see p. 67.)

May 1, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.6° (6 p. m.); after injection, reached in twelve hours, 106.2° (12 a. m.). (For complete record see p. 72.)

May 12, 1893: Killed for examination.

Autopsy.—A soft cheesy focus one-half inch in diameter in the left retropharyngeal gland.

Lungs: In the caudal lobe of the right lung on the lateral margin a small triangular area contains a few soft caseous foci and some more recent infiltration. In the caudal fifth of the same lobe there is a very small solitary, cheesy focus, and two of the same character in the same situation in the corresponding lobe of the left lung.

A much larger triangular focus of disease at the caudal border of the right ventral lobe consisting of an aggregation of cheesy masses up to one-fourth inch in diameter.

Thoracic glands: These are quite extensively diseased. That one of the series of posterior mediastinal glands which is situated near the arch of the aorta is fully 8 inches long and 5 inches wide. It is made up of a large number of communicating cavities filled with cheesy, partly liquefied matter. Another gland of the same series situated nearer the diaphragm is as large as a fist, and in the same condition as the preceding gland. The large mediastinal gland is not so far advanced. It contains a small number of cheesy tubercles and more or less recent infiltration. The 3 bronchial glands, one at the root of left bronchus, another at root of right bronchus, and the third at root of right supernumerary bronchus, are each as large as a fist, with contents cheesy and partly liquefied. A number of small glands not usually

detected in the normal lung, including the anterior mediastinal, are enlarged and contain one or more tuberculous foci.

Abdomen: On the tendinous portion of the diaphragm, mainly the right side, are a considerable number of flattish tubercular excrescences from one-eighth to three-fourths inch in diameter, consisting of agglomerations of tubercles some of which show slight central caseation. A thin membranous expansion extends from the diaphragm to the cephalic lobe of the liver, forming a false ligament. Along its free margin are a few tuberculous masses from one-eighth to one-fourth inch in diameter. One tubercle is firmly adherent to capsule of liver where the false ligament is attached to it. This mass is about one-half inch in diameter and one-fourth inch thick and made up of a capsule of dense connective tissue inclosing a firm yellowish caseous mass.

The parenchyma of the liver and the portal glands are normal.

The small extremity of spleen is adherent over an area about 6 inches square to reticulum by means of dense inflammatory tissue, one-half to 1 inch thick, containing abscesses and surrounded by gelatinous oedematous tissue. The spleen itself not affected. Cause, probably some foreign body.

No. 344.—Cow, fifteen-sixteenths Holstein, 6 years old. Weight, 900 pounds. Calved August, 1892; is giving milk. Pregnant since January 5, 1893.

March 27, 1893, midnight: First injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 101.8° (5 p. m.); after injection, reached in twelve hours, 105.2° (12 a. m.). (For complete record see p. 67.)

May 1, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.4° (6 p. m.); after injection, 102° (5 p. m.). (For complete record see p. 72.)

May 16, 1893: Killed for examination.

Autopsy.—In the right retropharyngeal gland are 3 tuberculous foci, each about one-half inch in diameter and consisting of grayish tissue penetrated by a network of yellowish lines.

No other tuberculous lesions discoverable.

Adhesion of cephalic end of liver to neighboring organs by means of inflammatory tissue containing a small abscess (traumatism). Sections of a portion of the retropharyngeal gland hardened in alcohol show that the region of the gland invaded is made up of a number of small foci, provided with giant cells.

No. 345.—Half Holstein cow, 9 years old. Weight, 1,000 pounds. Calved August, 1892; is giving milk. Pregnant since January 11, 1893.

March 27, 1893, midnight: First injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 101.6° (4 p. m.); after injection, reached in twelve hours, 106.9° (12 a. m.). (For complete record see p. 67.)

May 1, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection maximum temperature, 102.4° (6 p. m.); after injection, reached in nineteen hours, 106.4° (7 p. m.). (For complete record see p. 72.)

May 12, 1893: Killed for examination.

Autopsy.—The only tuberculous lesions in this case were found in the posterior mediastinal and the bronchial glands.

In the large posterior mediastinal gland there are about 6 foci one-eighth inch in diameter projecting as roundish bodies of a grayish translucent appearance above the cut surface. Each contains a yellowish necrotic center.

In the gland at root of left bronchus there are about 10 precisely similar foci. In the small gland at the root of the right bronchus, 1 similar focus.

Old fibrous adhesions between lungs and diaphragm, of slight extent.

No. 346.—Half Holstein cow, 9 years old. Weight, 1,000 pounds. Calved September, 1892; is giving milk. Pregnant since March 14, 1893.

March 27, 1893, midnight: First injection, 0.4 cc. tuberculin K. Before injection, maximum temperature, 101.8° (5 p. m.); after injection, reached in nineteen hours, 106.4° (7 p. m.). (For complete record see p. 67.)

May 1, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.6° (6 p. m.); after injection, reached in nineteen hours, 103.5° (7 p. m.). (For complete record see p. 72.)

May 16, 1893: Killed for examination.

Autopsy.—Thoracic glands: The gland at root of left bronchus made up of 3 separate glands. In one of these glands a tuberculous focus is one-fourth inch in diameter, of a gelatinous appearance, spongy, with yellowish particles sprinkled through it. In a second gland 3 similar foci, 2 one-fourth inch and 1 one-eighth inch in diameter. The large posterior mediastinal gland, about 5 inches long, one-half inch thick, and 2 inches wide at widest portion, contains tuberculous foci from one-half to one-fourth inch apart, situated mainly in the cortex. Foci most numerous at caudal end, where they are from one-eighth to one-fourth inch in diameter, and have a gelatinous appearance, with yellowish lines sprinkled in. They project above cut surface. These foci all appear to be of the same age, except two, one of which is about one-half inch in diameter and slightly older; the other is also one-half inch in diameter, and made up entirely of coarse, gritty particles. The gland at this point is retracted. In one of the more cephalic mediastinal glands 3 or 4 similar tuberculous foci.

Abdomen: In one mesenteric gland there is a tuberculous foci three-eighths inch in diameter, consisting of very firm cheesy material, in which is embedded a central calcareous particle. Traumatic inflammation around cephalic end of liver.

No. 347.—Holstein heifer, 2 years old. Weight, 600 pounds. Has never been served by bull.

April 12, 1893, midnight: First injection, 0.2 cc. tuberculin S.

April 13, 8:30 to 9 a. m.: Trembling very marked. Before injection, maximum temperature, 102.8° (4 p. m.); after injection, reached in sixteen hours, 106.8° (4 p. m.). (For complete record see p. 67.)

May 1, 1893, midnight: Second injection, 0.2 cc. tuberculin S. Before injection, maximum temperature, 103.6° (5 p. m.); after injection, reached in nineteen hours, 104.2° (7 p. m.). (For complete record see p. 72.)

May 5, 1893: Killed for examination.

Autopsy.—The tuberculous changes in this case are likewise confined to the thoracic lymph glands.

In three of the posterior mediastinal glands there are regions made up entirely of dense aggregations of grayish tubercles (recent infiltration). In one of these glands there is a small calcareous focus in the midst of the recent infiltration.

In the gland at the root of the left bronchus and in the one in the angle of bifurcation there are similar foci in which yellowish centers are visible.

No. 348.—Jersey cow, 8 years old. Weight, 800 pounds. Gave birth to triplets eighteen months ago and has not been in heat since; is not giving milk.

April 12, 1893, midnight: First injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.7° (4 p. m.); after injection, reached in seventeen hours, 106.2° (5 p. m.). (For complete record see p. 67.)

May 1, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.2° (8 p. m.); after injection, reached in seventeen hours, 103.2° (5 p. m.). (For complete record see p. 72.)

May 3, 1893: Killed for examination.

Autopsy.—Thorax: The large posterior mediastinal gland is 4 inches long and one-half inch thick (only slightly larger than normal). In the cortex are not less than 10 to 15 tuberculous foci up to one-fourth inch in diameter. Some are calcareous, others are in a state of partial necrosis. In another gland of the same group is a small calcareous focus.

Abdomen: In one mesenteric gland several small tuberculous foci. Horns of uterus more or less thickened (subinvolution). In the cavity some glairy fluid containing yellowish lumps.

No. 349.—Jersey cow, 4 years old. Weight, 750 pounds. Pregnant the first time since October 22, 1892.

April 12, 1893, midnight: First injection, 0.25 cc. tuberculin S.

April 13, 7:40 to 8:40 p. m.: Frequent and marked periods of trembling. Before injection, maximum temperature, 102.6° (4 p. m.); after injection, reached in ten hours, 106.7° (10 a. m.). (For complete record see p. 68.)

May 1, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102° (4 p. m.); after injection, reached in nineteen hours, 103.8° (7 p. m.). (For complete record see p. 72.)

May 5, 1893: Killed for examination.

Autopsy.—The tuberculous changes are limited to the thoracic lymph glands.

The bronchial gland at root of left bronchus as large as a hen's egg, more or less furrowed and lobulated. Its center is occupied by a completely calcified focus three-eighths inch in diameter. Throughout the remainder of the gland are disseminated yellowish foci one-eighth inch in diameter and one-eighth to one-fourth inch apart, projecting above the cut surface. In the large posterior mediastinal gland there are several foci of disease. One, near one extremity of the gland which is more or less nodulated, consists of an aggregation of small tubercles containing yellowish calcareous nuclei. In the center of the gland there is an aggregation of partly caseous tubercles surrounded by a zone of more recent infiltration.

No. 350.—Jersey bull, 6 years old. Weight, 1,400 pounds.

April 12, 1893, midnight: First injection, 0.35 cc. tuberculin S.

April 13, 8:30 to 9:30 a. m.: Very uneasy in stall. Stands with body drawn up and back very much arched. Very violent and continuous trembling. Before injection, maximum temperature, 101.6° (3 p. m.); after injection, reached in ten hours, 106° (10 a. m.). (For complete record see p. 68.)

May 1, 1893, midnight: Second injection, 0.35 cc., tuberculin S. Before injection, maximum temperature, 102.2° (5 p. m.); after injection, reached in seventeen hours, 105° (5 p. m.). (For complete record see p. 72.)

May 10, 1893: Killed for examination.

Autopsy.—In gland at root of left bronchus there is a considerable crop of minute grayish tubercles, about one-sixteenth inch in diameter, and situated mainly in the cortex. A few are larger than the rest and contain each a minute yellowish nucleus. The small gland at root of right main bronchus contains three tubercles undergoing necrosis, each one-sixteenth to one-eighth inch in diameter.

In one of the mediastinal glands a few small tubercles like those in left bronchial gland.

No. 351.—Holstein bull, 2 years old. Weight, 850 pounds.

April 12, 1893, midnight: First injection, 0.25 cc., tuberculin S.

April 13, 8 to 9 a. m.: Periods of very violent trembling every few seconds, amounting almost to a violent shaking of the whole body. Before injection, maximum temperature, 102.6° (5 p. m.); after injection, reached in nineteen hours, 106.7° (7 p. m.). (For complete record see p. 68.)

May 1, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.4° (6 p. m.); after injection, reached in nineteen hours, 105.6° (7 p. m.). (For complete record see p. 72.)

May 3, 1893: Killed for examination.

Autopsy.—Lungs: There are not less than 5 tuberculous foci in the lung tissue. One large one, 2 to 3 inches in diameter near the lateral margin of the left caudal lobe, projecting slightly above the dorsal surface of the lobe when in state of collapse. It consists of soft cheesy masses easily removed from the enveloping tissue. The surrounding lung tissue is infiltrated with young tubercles. A second focus, 1 inch in diameter, situated along median border of the same lobe deeply embedded in the lung tissue. The condition of this focus the same as that of the first.

Two smaller soft cheesy foci situated near cephalic margin of the same lobe each one-half to three-fourths inch in diameter.

Three quite small glands embedded in the lung tissue of this lobe between the pulmonary artery and main bronchus contain firm, partly necrotic foci. In the main bronchus near its root a few submucous tubercles. In the right cephalic lobe there is 1 soft cheesy focus about one-half inch in diameter.

Bronchial glands: The one at root of left bronchus about the size of a small fist. The one at root of right supernumerary bronchus contains 10 to 15 tuberculous foci. The one situated in the bifurcation is as large as a hen's egg and almost entirely converted into a caseous mass in which are embedded gritty particles. The posterior mediastinal glands are also involved and contain numerous foci from one-eighth to one-half inch apart, the larger soft and cheesy.

In general, all thoracic glands affected and a few large glands noted where in normal lungs they are so minute as to be overlooked.

The bronchial glands are further advanced in disease than the mediastinals.

One gland removed with spleen, and in all probability belonging to the portal glands, contains two tuberculous foci, yellowish, cheesy, still firm, and partly calcareous.

No. 352.—Holstein cow, 3 years old. Weight, 700 pounds. Calved March 19, 1893, and has not been served by bull since; is giving milk.

April 12, 1893, midnight: First injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 103° (6 p. m.); after injection, reached in ten hours, 106.2° (10 a. m.). (For complete record see p. 68.)

May 1, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 104° (5 p. m.); after injection, reached in seven hours, 104.3° (7 a. m.). (For complete record see p. 73.)

May 10, 1893: Killed for examination.

Autopsy.—Left retropharyngeal gland about 2 inches in diameter, slightly irregular in shape. On section the parenchyma is found containing tuberculous foci made up of putty-like masses, mixed with a few calcareous particles. They vary from one-eighth to 1 inch in diameter, and are surrounded with considerable connective tissue.

No. 353.—Jersey cow, 4 years old. Weight, 600 pounds. Calved March 26, 1893, and has not been served by bull since; is giving milk.

April 12, 1893, midnight: First injection, 0.25 cc. tuberculin S. Before injection maximum temperature 102.6° (4 p. m.); after injection, reached in seventeen hours, 103.8° (5 p. m.). (For complete record see p. 68.)

May 1, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, minimum temperature 102.6° (5 p. m.); after injection, reached in nineteen hours, 104.3° (7 a. m.). (For complete record see p. 73.)

May 3, 1893: Killed for examination.

Autopsy.—No tuberculous lesions were found in this animal.

No. 354.—Cow, fifteen-sixteenths Holstein, 9 years old. Weight, 1,100 pounds. Calved March 28, 1893, and has not been served by bull since; is giving milk.

May 1, 1893, midnight: First injection, 0.25 cc. tuberculin S. Before injection, maximum temperature 103.5° (6 p. m.); after injection, reached in twelve hours, 106° (12 a. m.). (For complete record see p. 68.)

May 25, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature 102.6° (6 p. m.); after injection, reached in eighteen hours, 103° (6 p. m.). (For complete record see p. 73.)

June 8, 1893: Killed for examination.

Autopsy.—Thorax: In the lungs there are 4 foci of tuberculous infection, all situated in the caudal lobes. They are best described separately.

Focus No. 1 is situated on the median edge of right caudal lobe about 1½ inches from caudal tip. The focus itself is about 1½ inches long and nearly three-fourths inch in

diameter; a few distended tortuous vessels pass over its surface. It feels as if made up of four or five quite firm and distinct foci. A small air tube leads directly to the focus, and along its course there are several small tuberculous foci in connection with its walls. The large focus is composed of several small foci easily separated by teasing. Each contains a pasty, pale-yellow mass, inclosed in a rather thin capsule. The remaining foci are situated in the left caudal lobe.

Focus No. 2 occupies a position symmetrical with No. 1. It does not show on the surface as does No. 1, but is easily felt with the fingers; slight catarrh of the air tube leading to this focus. It consists of about one-half dozen nodules up to one-half inch in diameter, situated around a somewhat dilated bronchiole. In the course of the main bronchus and about 3 inches from the tip of lobe and about 2 inches from the focus just described there are several small cheesy foci in connection with the walls of the bronchus.

Focus No. 3 consists of a mass of firm nodules, varying in size up to one-half inch in diameter and distributed over a region about $2\frac{1}{2}$ inches square and one-half inch thick. Small air tubes are traceable in this focus. The larger nodules are cheesy, like those described. There is some slight recent infiltration in the periphery of the focus. The interlobular tissue is more or less increased in quantity.

Focus No. 4 consists of a number of small cheesy nodules, up to one-eighth inch in diameter, covering an area of about 1 cubic inch and embedded in a large amount of firm connective tissue. There is in one place some recent infiltration on the periphery.

The gland at the root of left bronchus is more or less irregular and nodular in outline, and contains a considerable quantity of connective tissue, and in its center a cheesy mass about one-quarter inch in diameter. Scattered over the periphery are three or four quite small gelatinous looking tuberculous foci, containing yellowish necrotic masses. In the gland at root of the right supernumerary bronchus, which is but slightly enlarged, there are three tuberculous foci from one-eighth to one-half inch in diameter, with cheesy contents. The gland situated on dorsal surface of trachea near supernumerary bronchus contains one gelatinous focus, yellowish in color, and about three-sixteenths inch in diameter. The most caudal of the posterior mediastinal glands is very irregular in outline, much nodulated and retracted. The gland is of the usual length, and at its thickest portion is 1 by $1\frac{1}{4}$ inches thick. In the center of this enlarged portion there is a cheesy mass, surrounded by connective tissue from one-half to three-fourths inch in diameter. The nodules showing from the exterior are, in part, free from any tuberculous deposit, and are due to retraction of the gland tissue, probably a result of some previous infection. In one of the smaller mediastinal glands there are three quite small gelatinous-looking nodules. The small gland within the left caudal lobe, between bronchus and artery near their origin, contains two tuberculous foci.

No. 355.—Holstein cow, 5 years old. Weight, 900 pounds. Calved summer of 1892. Pregnant since August 31, 1892.

May 1, 1893, midnight: First injection, 0.25 cc. tuberculin S. Before injection, maximum temperature 102.8° (5 p. m.); after injection, reached in fourteen hours, 105.4° (2 p. m.). (For complete record see p. 68.)

May 25, 1893, midnight: Second injection, 0.25 cc., tuberculin S. Before injection, maximum temperature, 103.2° (8 p. m.); after injection, 102.8° (7 a. m.). (For complete record see p. 73.)

June 8, 1893: Killed for examination.

Autopsy.—Thorax: On the surface of the large posterior mediastinal gland there are two round, projecting yellow, nodules, one-eighth and one-sixteenth inch in diameter. They are calcareous and the surrounding tissue free from any infiltration.

In the bronchial gland, at root of left bronchus, 3 foci of similar size and character.

Abdomen: In one of the mesenteric glands there is a group of three firm yellowish tubercles (the whole one-fourth inch in diameter) in the cortical portion. In a neighboring gland there is a similar group of somewhat larger tuberculous nodules. The glands are not enlarged and there is no infiltration around the foci.

No. 356.—Cow, fifteen-sixteenths Holstein, 9 years old. Weight, 1,000 pounds. Calved November, 1892; is giving milk. Served by bull March 6, 1893, but is not pregnant.

May 1, 1893, midnight: First injection, 0.25 cc. tuberculin S. Before injection, maximum temperature 102° (4 p. m.); after injection, reached in seventeen hours, 104° (5 p. m.). (For complete record see p. 68.)

May 25, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature 102° (6 p. m.); after injection, reached in eighteen hours, 102.8° (6 p. m.). (For complete record see p. 73.)

June 12, 1893: Killed for examination.

Autopsy.—Thorax: In the caudal lobe of the left lung there is a tuberculous focus, situated directly under the pleura of the dorsal surface close to the median edge and 4 or 5 inches from the caudal tip. The pleura over this focus is slightly opaque, and beneath it are three small tuberculous nodules, two of which contain a caseous center. The focus itself consists of a central soft caseous mass, inclosed in a rather thick-walled capsule and surrounded by a zone of infiltrated tissue one-fourth to one-half inch thick. The infiltration consists of tubercles up to one-eighth inch in diameter, many of them caseous. An air tube is not traceable to it.

In the bronchus of this same lobe near its origin and in the trachea are 2 grayish tubercular excrescences. The one in the trachea is about one-half inch in diameter and projects one-half inch above surface. The center is depressed. The whole appears as if the mucosa were lifted up by tubercular infiltration of the submucosa. Section of the tumor shows a caseous mass beneath. The excrescence in the bronchus is more convex and projecting, otherwise there are no marked differences.

In the large posterior mediastinal gland near one end are 4 completely calcified foci about one-eighth to one-fourth inch in diameter. The gland itself is not enlarged, and these foci feel as firm as bullets in the interior of the gland tissue.

No. 357.—Cow, fifteen-sixteenths Holstein, 8 years old. Weight, 1,000 pounds. Calved July 1, 1893; is giving milk.

May 1, 1893, midnight: First injection, 0.25 cc. tuberculin S. Before injection, maximum temperature 102.8° (6 p. m.); after injection, reached in fourteen hours, 103° (2 p. m.). (For complete record see p. 68.)

May 25, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature 105° (10 p. m.); after injection, 102.5° (7 a. m.). (For complete record see p. 73.)

The elevation in temperature previous to inoculation was due to an unknown cause; excepting it the cow was apparently in good health. She belonged to the last of the series of tests in this herd, else a third injection of tuberculin would have been made. (See Case No. 318.)

July 13, 1893: Killed for examination.

Autopsy.—Tuberculous lesions not discoverable. In the udder a number of completely yellow regions indicating fatty degeneration of gland substance.

Marked interlobular and subpleural emphysema of the cephalic and ventral lobes of the right lung and of the ventral lobe of the left lung. Uterus contains a milky, very foul-smelling fluid. Calf born thirteen days ago.

No. 358.—Cow, fifteen-sixteenths Holstein, 6 years old. Weight, 1,000 pounds. Calved summer of 1892; is still giving milk. Pregnant since January 20, 1893.

May 1, 1893, midnight: First injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102° (5 p. m.); after injection, reached in nineteen hours, 105.6° (7 p. m.). (For complete record see p. 68.)

May 25, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 101.8° (6 p. m.); after injection, reached in seventeen hours, 102.9° (5 p. m.). (For complete record see p. 73.)

May 27, 1893: Killed for examination.

Autopsy.—Thorax: The most caudal of the posterior mediastinal glands has its cephalic end considerably enlarged, three-fourths inch thick, and $1\frac{1}{2}$ inches wide. On section the greater part is found to be in a condition of tuberculous infiltration, of a grayish appearance, in which are embedded a considerable number of soft cheesy foci containing a few gritty particles. One of these cheesy foci is fully one-half inch in diameter. Along the middle portion of the same gland is another tuberculous mass about 1 by $\frac{1}{2}$ inch in size, containing 4 foci, some of which are firm and yellow, others are still grayish with yellowish lines within them.

The second gland of this group has about one-fourth of its mass in the same condition as that just described. This gland is about 1 by $\frac{1}{2}$ by $\frac{1}{4}$ inch in size. The third gland of the group, slightly larger than the second, is normal. The fourth gland, which is $1\frac{1}{2}$ by 1 by $\frac{1}{2}$ inch has two-thirds of its substance in the same tuberculous condition. The fifth, sixth, and seventh glands of this group are normal.

The bronchial gland at root of right bronchus is slightly larger than normal and contains a region of grayish infiltration about 1 inch in diameter, containing 6 or more small yellowish foci, quite firm and gritty in the center. One mesenteric gland contains in its cortex a dozen or more small tubercles, some yellowish and nearly one-eighth inch in diameter, projecting markedly above the cut surface.

Traumatic inflammatory adhesion between second stomach and neighboring organs.

No. 359.—Holstein cow, 7 years old. Weight, 1,000 pounds. Calved, July, 1892; is still giving milk. Pregnant since August 25, 1892.

May 1, 1893, midnight: First injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 103.2° (6 p. m.); after injection, reached in fourteen hours, 107.3° (2 p. m.). (For complete record see p. 68.)

May 25, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 103.4° (6 p. m.); after injection, 103° (6 p. m.). (For complete record see p. 73.)

May 26, 8 p. m.: The cow gave birth to a healthy calf, after which the temperatures were no longer taken.

June 15, 1893: Killed for examination.

Autopsy.—Thorax: In the right caudal lobe near the median border on the dorsal aspect, and about midway between caudal and cephalic border there is a small focus about 1 to $1\frac{1}{4}$ inches in diameter directly under the pleura, made up of a collection of foci in various stages of degeneration. The innermost are soft, caseous, and surrounded by a thick wall. Several of these communicate directly by means of small openings with a small, dilated bronchus filled with yellowish, cheesy matter. Some of the exterior foci are composed of a very thick grayish wall and a small, very soft, yellowish center. These are about one-fourth inch in diameter.

Large posterior mediastinal gland, the most caudal of the series, is of the usual size, but is found to contain firm nodules in its substance. On the flat surface opposite the hilus there is a collection of nodules projecting above the surface, which on section are made up of a central, yellowish core, surrounded by a grayish capsule. On cutting into the gland there are found four or five separate regions of disease, consisting each of one or more foci one-eighth to one-fourth inch in diameter, which are firm, grayish on section, and have a yellowish, necrotic center. There is only one gritty focus about one-eighth inch in diameter.

The next gland of the series is about 1 inch in diameter and contains about 4 one-fourth-inch foci, all in the same condition as those described. The third gland, about 1 inch in diameter, contains 1 such focus. The fourth gland, $\frac{3}{4}$ by $\frac{1}{2}$ inch in size, contains 5 or 6 similar foci and 1 smaller gritty focus. The fifth gland, about one-half

inch in diameter, is very nodular and contains 1 central, completely calcified focus and several peripheral foci with necrotic centers, like preceding. The sixth gland is about 2 inches long, one-half inch thick, and feels very nodular to the touch. It contains about one dozen foci from one-eighth to one-fourth inch in diameter, made up of a grayish peripheral zone and a firm necrotic center. The seventh gland is about 1½ inches long, one-fourth inch thick, and contains 3 foci like those described. The small gland between the two bronchi at the bifurcation, which is about one-half inch in diameter, is almost entirely occupied by 2 foci, one-eighth and three-eighths inch in diameter, of the same character as the preceding.

No. 360.—Cow, fifteen sixteenths Holstein, 9 years old. Weight, 1,000 pounds. Calved April 12, 1893, and has not since been served by bull; is giving milk.

May 1, 1893, midnight: First injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.4° (4 p. m.); after injection, 102.8° (7 p. m.). (For complete record see p. 68.)

May 25, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.2° (6 p. m.); after injection, 102.5° (6 p. m.). (For complete record see p. 73.)

July 6, 1893: Killed for examination.

Autopsy.—In the large posterior mediastinal gland there are 3 tuberculous foci situated near the middle of the gland. They are respectively one-half, one-half, and one-fourth inch in diameter. They are completely caseous, without any surrounding infiltration, and embedded in considerable connective tissue, part of which seems to belong to the scar of a healed infection. Slight adhesion of cephalic end of liver. A guinea pig inoculated subcutaneously with some of the caseous material July 7 died just two months after inoculation. The usual lesions of tuberculosis (advanced tuberculosis of liver, tubercles in lungs, and in Peyer's patches of the intestines) were present.

No. 361.—Holstein cow, 8 years old. Weight, 950 pounds. Calved December, 1892, and is giving milk. Pregnant since March 9, 1893.

May 1, 1893, midnight: First injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.6° (5 p. m.); after injection, reached in nineteen hours, 105.8° (5 p. m.). (For complete record see p. 69.)

May 25, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.4° (8 p. m.); after injection, 102.5° (7 a. m.). (For complete record see p. 73.)

May 27, 1893: Killed for examination.

Autopsy.—In the large posterior mediastinal gland there is 1 small, completely calcified focus about one-eighth inch in diameter. It shows on the exterior as a slight cicatricial constriction. There is 1 other calcified focus not more than one-sixteenth inch in diameter. The gland itself is slightly larger than normal and shows evidences of former inflammation. The left abdominal aspect of the diaphragm is very much thickened by inflammatory tissue of almost cartilaginous firmness. The lesion is limited mainly to the muscular portion of the diaphragm, and covers an area 4 to 6 inches in diameter. There is also considerable inflammatory deposit in the form of a gelatinous exudate between the second stomach and the liver. In this deposit are embedded a few suppurative foci.

No. 362.—Holstein cow, 11 years old. Weight, 1,100 pounds. Calved early in summer of 1892, and is still giving milk. Pregnant since February 9, 1893.

May 1, 1893, midnight: First injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.8° (5 p. m.); after injection, reached in eleven hours, 104.8° (11 a. m.). (For complete record see p. 69.)

May 25, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.4° (8 p. m.); after injection, reached in eighteen hours, 103° (6 p. m.). (For complete record see p. 73.)

June 12, 1893: Killed for examination.

Autopsy.—Thorax: In the caudal lobes of both lungs there are three tuberculous foci:

(1) In the left caudal lobe, about 1 inch from caudal extremity, is a collection of two or three caseous, quite soft foci, the whole about one-half inch in diameter, inclosed in more or less connective tissue, and with periphery free from recent infiltration.

(2) Exactly corresponding in position to the preceding focus is one in the right caudal lobe, consisting of a soft, cheesy mass inclosed in a capsule.

(3) In the left caudal lobe there is a second focus situated near median border of lobe on its dorsal aspect and about 3 or 4 inches from the caudal tip of lobe. This focus, $1\frac{1}{4}$ or 2 inches in diameter, on first cutting into it, appeared as a very recent infiltration. The almost normal lung tissue is studded with an immense number of miliary tubercles. On closer examination a contiguous focus of small caseous masses is found, and a small dilated air tube choked with caseous material in communication with this region.

The large posterior mediastinal gland contains three foci about one-fourth inch in diameter. These appear as grayish, gelatinous-looking masses projecting above the cut surface and containing some yellowish gritty particles. One of the other glands of this series contains two small foci of the same character.

Bronchial gland at the root of left bronchus contains about six similar foci. The glands at root of right bronchus, the one at the bifurcation, and the one at the root of the right supernumerary bronchus contain each a single similar focus.

Three mesenteric glands contain each several small, firm, yellow tubercles. A fourth gland is as large as a hen's egg, and on section the medullary portion is found converted into a yellowish, still firm, necrotic mass.

No. 363.—Cow, seven-eighths Holstein, 9 years old. Weight, 950 pounds. Calved January 31, 1893, and has not since been served by bull; is giving milk.

May 1, 1893, midnight: First injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 103.2° (6 p. m.); after injection, reached in fourteen hours, 106° (2 p. m.). (For complete record see p. 69.)

May 25, 1893, midnight: Second injection, 0.25 cc. tuberculin S. Before injection, maximum temperature, 102.8° (8 p. m.); after injection, 102.7° (5 p. m.). (For complete record see p. 73.)

June 19, 1893: Killed for examination.

Autopsy.—One of the retropharyngeal glands is somewhat enlarged and contains a cheesy focus from one-half to three-fourths inch in diameter. The very soft contents are surrounded by distinct, connective-tissue capsule.

Thorax: In the large posterior mediastinal gland, which is not visibly enlarged, there is in the middle of its length along one border a region about 2 inches long which appears very nodular from the exterior and feels firm and nodular to the touch. In this mass only one distinctly tuberculous focus is found. This is about three-sixteenths inch in diameter, firm, yellowish, and projecting markedly above the cut surface. One other minute yellowish focus discovered in this gland. In one other mediastinal gland there is some firm, cicatricial tissue in the cortex indicative of healed tuberculosis. In the gland situated on the dorsal aspect of the trachea, near the right supernumerary bronchus, there is a similar circumscribed mass of very fine nodular tissue and a minute yellowish tubercle. The right ventral and principal lobes are firmly adherent to the diaphragm by means of delicate connective-tissue expansions. Similar slight attachments are found between pericardium and diaphragm and pericardium and the smaller lobes.

Abdomen: Over the cephalic half of the convex surface of the liver there are a number of old, fibrous adhesions attaching the anterior to cephalic lobe and the diaphragm. In the same lobe are several regions of yellowish infiltration, probably of embolic origin and due to parasites.

Some of the coils of the small intestines are attached to the abdominal wall by expansions of thin, membranous connective tissue. In many of the mesenteric glands there are one or more worm tubercles.

The following case, one of the three bulls, was sent to the experiment station of the bureau November 14, 1892, some months before the general test of the herd was begun. On November 17 one of the cervical glands* was removed by Dr. Kilborne. It was 3 to 4 inches in diameter, composed of a thick-walled sac and semifluid contents. Two guinea pigs inoculated subcutaneously with some of the contents died of tuberculosis.

Three tuberculin injections were made in all, the results of which are given below:

First test.—Received an injection November 16, 6:30 a. m., of 0.5 cc. tuberculinum Kochii.

<i>Temperature before injection.</i>		<i>Temperature after injection.</i>	
Nov. 14—4:30 p. m.†	104.3	Nov. 16—6:30 a. m.	101.4
6:30 p. m.	102.2	9 a. m.	102.7
Nov. 15—8 a. m.	100.0	11 a. m.	103.6
12 m.	100.2	1 p. m.	104.2
4 p. m.	100.9	3 p. m.	104.2
8 p. m.	101.6	5 p. m.	104.6
		7 p. m.	103.6
		9 p. m.	103.0
		11 p. m.	102.4
		Nov. 17—8 a. m.	101.0
		1 p. m.	102.4
		5 p. m.	101.2

November 17, 1892: Excision of the tubercular gland.

Second test.—Received an injection December 10, 1892, 6:30 a. m., of 0.15 cc. tuberculin prepared in the chemical laboratory of the Bureau of Animal Industry.

<i>Temperature before injection.</i>		<i>Temperature after injection.</i>	
Dec. 9—8 a. m.	101.0	Dec. 10— 6:30 a. m.	101.0
1 p. m.	100.8	9 a. m.	101.2
5 p. m.	101.8	11:30 a. m.	102.2
		2 p. m.	102.0
		4 p. m.	102.0
		6 p. m.	103.2
		8 p. m.	103.0
		11 p. m.	102.8
		Dec. 11— 8 a. m.	101.4
		4 p. m.	102.8
		Dec. 12— 8 a. m.	101.0

*Probably the one denominated post maxillary in this bulletin.—T. S.

†Temperature taken immediately upon the arrival of the bull at the veterinary station after he had been walking 3 to 4 miles from the Soldiers' Home.

Third test.—Received an injection January 20, 1893, 7 a. m., of 0.35 cc. tuberculin prepared in the chemical laboratory of the Bureau of Animal Industry.

* Temperature before injection.		Temperature after injection.	
Jan. 19— 8 a. m.	101.0	Jan. 20— 7 a. m.	100.8
12 m.	101.4	9 a. m.	102.2
5 p. m.	101.0	11 a. m.	103.0
		1 p. m.	102.6
		3 p. m.	102.6
		6 p. m.	101.5
		8 p. m.	101.2
		10 p. m.	101.0
		Jan. 21— 8 a. m.	100.5
		12 m.	100.8
		5 p. m.	102.6

January 26, 1893: Bull killed and examined post-mortem.

Extensive tuberculosis of glands of head. Tuberculosis of bones of sternum Axillary glands of both sides as large as hens' eggs and cheesy.

Advanced tuberculosis of all lobes of the lungs, associated with cavities and more or less fibroid induration. No pleural tuberculosis. All thoracic glands tuberculous and some as large as the closed hand.

In abdomen, mesenteric glands as well as the peritoneum free from disease. The portal glands free, but four cheesy foci in the liver tissue, one-half to 1 inch in diameter. Spleen free. Some small tubercles in medullary portion of parenchyma of kidneys near papillæ.

In this animal the advanced stage of the gland disease, the cavities in the lungs, the surrounding fibroid thickening, and the chronic generalized infection indicate that this was a long-standing case.

TABLES GIVING THE TEMPERATURE AS TAKEN BEFORE AND AFTER THE INJECTION OF TUBERCULIN.

By F. L. KILBORNE and E. C. SCHROEDER.

Hour.	303		304		306		311		314	
	Dec. 6. Before.	Dec. 7. After.	Dec. 6. Before.	Dec. 7. After.	Dec. 6. Before.	Dec. 7. After.	Dec. 6. Before.	Dec. 7. After.	Dec. 6. Before.	Dec. 7. After.
6 a. m.	102.0	102.2	100.8	101.5	101.4	101.8	101.5	101.6	101.2	101.8
8 a. m.	102.5	102.5	101.8	102.2	102.6	103.0	102.5	102.6	102.0	101.8
10 a. m.	102.2	102.0	101.8	101.8	102.0	102.5	101.8	102.0	102.4	102.2
12 noon	100.2	100.4	101.5	99.4	100.0	100.2	99.6	99.5	99.8	99.8
2 p. m.	100.8	104.4	101.0	101.2	100.6	102.4	100.2	101.8	101.2	102.5
4 p. m.	102.2	107.0	101.8	102.4	101.8	105.2	101.4	104.8	102.5	105.0
6 p. m.	102.5	106.6	102.2	102.6	102.3	105.8	101.5	106.0	102.2	105.6
8 p. m.	101.5	105.4	101.2	102.5	101.4	106.0	101.2	104.4	101.6	106.0
9 p. m.		105.0		102.2		105.2		105.1		105.3
11 a. m., Dec. 8		100.7		101.0		101.0		101.0		100.8

Injected tuberculin K 6 a. m. December 7, 1892.

Temperature as taken before and after the injection of tuberculin—Continued.

Hour.	301						302					
	Feb. 1-2. Before injection.			Feb. 2-3. After injection.			Feb. 1-2. Before injection.			Feb. 2-3. After injection.		
	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.
9 a. m.	100.2	.....	.....	101.4	54	24	100.0	.....	.....	101.2	54	24
10 a. m.	100.1	.....	.....	101.4	54	24	100.0	.....	.....	101.6	54	18
11 a. m.	100.6	54	16	101.8	54	21	100.6	54	16	101.3	54	18
12 noon	101.1	50	18	101.3	54	24	100.6	48	16	101.0	54	21
1 p. m.	101.4	54	18	101.2	54	21	100.6	54	20	101.0	54	18
2 p. m.	101.6	54	30	101.4	54	18	101.0	48	18	101.3	54	18
3 p. m.	102.0	78	36	101.7	51	18	101.4	72	32	102.9	60	21
4 p. m.	101.8	72	36	102.8	90	24	102.2	72	32	104.0	72	30
5 p. m.	101.8	60	30	103.3	90	30	101.5	66	30	105.4	96	30
6 p. m.	101.6	60	32	105.0	75	30	101.4	60	30	106.6	84	36
7 p. m.	101.2	60	30	106.4	84	24	101.0	60	30	107.4	96	33
8 p. m.	101.5	54	30	106.6	84	30	101.0	54	28	107.0	90	36
9 p. m.	101.4	54	28	106.8	78	30	101.0	54	28	106.5	84	30
10 p. m.	101.4	54	30	106.4	78	36	101.3	54	30	106.0	84	30
11 p. m.	101.4	56	30	105.8	72	27	101.4	54	30	106.0	84	30
12 midnight	101.6	60	30	106.2	75	30	100.8	70	30	105.6	75	27
1 a. m.	101.4	54	26	105.8	84	30	101.4	66	30	105.0	72	30
2 a. m.	101.5	56	30	105.8	66	27	101.0	60	30	105.3	69	36
3 a. m.	101.4	54	32	105.0	78	39	100.8	54	27	104.8	72	30
4 a. m.	100.9	54	32	105.2	66	30	101.2	54	24	104.8	72	36
5 a. m.	101.6	54	30	104.4	78	36	101.7	54	21	103.9	72	36
6 a. m.	101.9	72	30	104.0	72	36	101.6	66	30	103.4	75	30
7 a. m.	101.6	48	18	103.2	72	42	101.7	60	21	103.1	66	32
8 a. m.	101.3	54	18	102.8	60	36	101.8	54	24	102.5	69	36
9 a. m.	Inj. tuberculin S.	.....	.....	102.4	60	40	Inj. tuberculin S.	.....	.....	102.4	66	30
10 a. m.	.....	.....	.....	101.6	60	24	.....	.....	.....	101.8	60	24
11 a. m.	.....	.....	.....	101.2	54	24	.....	.....	.....	101.8	57	27
12 noon	.....	.....	.....	101.2	66	33	.....	.....	.....	101.8	60	24
1 p. m.	.....	.....	.....	101.2	54	33	.....	.....	.....	101.8	60	24
2 p. m.	.....	.....	.....	101.2	57	39	.....	.....	.....	101.6	60	30
3 p. m.	.....	.....	.....	102.0	72	33	.....	.....	.....	102.5	68	32
4 p. m.	.....	.....	.....	102.2	78	36	.....	.....	.....	103.2	72	36

Hour.	303 *						304 *					
	Feb. 1-2. Before injection.			Feb. 2-3. After injection.			Feb. 1-2. Before injection.			Feb. 2-3. After injection.		
	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.
9 a. m.	99.1	.....	.....	101.5	54	27	98.6	.....	.....	102.2	54	24
10 a. m.	99.0	.....	.....	101.0	48	12	99.0	.....	.....	102.1	48	21
11 a. m.	100.0	48	20	100.6	48	18	98.8	48	12	102.2	51	21
12 noon	100.0	50	18	100.3	48	18	100.0	50	12	101.4	51	18
1 p. m.	100.0	50	20	100.6	57	24	100.9	48	16	101.2	54	18
2 p. m.	100.8	48	20	100.4	48	21	101.2	54	18	101.8	51	18
3 p. m.	101.6	70	40	101.8	51	24	101.8	72	32	101.9	48	21
4 p. m.	102.0	76	35	103.0	66	30	102.3	70	36	102.3	78	36
5 p. m.	101.8	66	24	103.7	72	33	101.7	66	30	102.3	72	24
6 p. m.	101.5	66	30	104.1	66	30	101.7	56	22	102.6	69	24
7 p. m.	101.2	60	30	105.2	60	36	101.4	62	26	102.0	60	21
8 p. m.	101.2	54	26	105.6	63	33	101.2	54	20	101.4	60	21
9 p. m.	101.0	60	36	104.8	63	30	101.4	60	30	101.6	60	24
10 p. m.	100.9	60	36	105.4	63	24	101.2	56	30	101.4	60	24
11 p. m.	101.3	66	30	104.2	72	36	101.6	54	24	101.6	60	24
12 midnight	101.0	54	30	104.0	72	36	101.0	54	24	101.6	60	21
1 a. m.	100.8	54	36	103.8	57	27	100.8	60	24	101.8	63	18
2 a. m.	101.0	50	32	104.0	66	42	101.2	60	24	101.4	60	15
3 a. m.	100.8	48	21	104.0	63	33	101.5	54	24	101.4	66	18
4 a. m.	100.8	54	30	103.8	72	39	101.4	54	24	101.6	60	24
5 a. m.	101.4	48	24	103.0	60	38	102.2	54	24	101.2	60	24
6 a. m.	101.4	54	24	103.2	66	36	101.8	60	24	102.0	66	22
7 a. m.	101.4	48	24	103.4	63	45	101.9	54	21	101.5	57	15
8 a. m.	101.6	60	24	103.0	66	48	101.8	60	24	101.4	60	24
9 a. m.	Inj. tuberculin S.	.....	.....	102.5	66	42	Inj. tuberculin S.	.....	.....	101.7	66	24
10 a. m.	.....	.....	.....	102.0	54	33	.....	.....	.....	101.0	57	21
11 a. m.	.....	.....	.....	102.0	54	30	.....	.....	.....	101.0	60	18
12 noon	.....	.....	.....	101.6	54	36	.....	.....	.....	100.8	54	24
1 p. m.	.....	.....	.....	101.4	60	33	.....	.....	.....	101.0	54	18
2 p. m.	.....	.....	.....	101.8	54	33	.....	.....	.....	101.4	54	24
3 p. m.	.....	.....	.....	102.4	78	42	.....	.....	.....	102.0	72	36
4 p. m.	.....	.....	.....	103.2	68	48	.....	.....	.....	102.0	72	36

* Given a preliminary tuberculin test December 7, 1892.

Temperature as taken before and after the injection of tuberculin—Continued.

Hour.	305						306*					
	Feb. 1-2.			Feb. 2-3.			Feb. 1-2.			Feb. 2-3.		
	Before injection.			After injection.			Before injection.			After injection.		
	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.
9 a.m.	99.4	.....	.....	101.6	45	21	100.6	.....	.....	101.6	50	30
10 a.m.	99.4	.....	.....	101.5	48	21	99.6	.....	.....	101.8	54	21
11 a.m.	100.4	42	12	101.6	48	18	100.4	50	16	102.1	42	18
12 noon	100.4	42	12	101.0	42	15	100.6	44	18	100.8	42	21
1 p.m.	100.8	48	12	100.7	48	15	101.2	54	20	100.4	45	18
2 p.m.	101.0	48	18	101.2	48	18	101.2	50	26	101.0	45	21
3 p.m.	101.8	70	30	101.2	45	21	101.9	66	36	101.8	48	21
4 p.m.	101.8	78	30	102.1	72	30	102.0	72	30	102.4	72	30
5 p.m.	101.4	66	24	102.8	75	30	101.4	62	24	102.2	72	36
6 p.m.	101.2	51	24	102.0	54	24	101.1	54	36	102.2	54	24
7 p.m.	101.3	56	24	101.8	54	18	100.8	54	28	102.0	54	24
8 p.m.	100.7	54	24	101.6	60	21	100.9	54	30	104.0	60	27
9 p.m.	101.0	50	30	100.6	54	18	100.6	54	30	105.3	66	36
10 p.m.	101.0	54	26	101.0	54	18	100.8	48	30	106.4	72	33
11 p.m.	101.0	54	20	101.0	54	18	100.8	66	30	106.0	75	33
12 midnight	101.0	48	20	101.6	48	15	100.8	48	32	105.8	60	30
1 a.m.	101.0	48	24	101.2	51	18	100.9	48	24	104.4	72	48
2 a.m.	101.4	54	27	101.6	78	15	101.0	45	30	103.4	60	42
3 a.m.	100.8	57	24	101.2	60	24	100.7	48	24	103.5	63	39
4 a.m.	101.4	54	24	101.2	54	15	100.8	48	24	103.8	63	33
5 a.m.	101.2	54	20	101.0	57	20	101.3	54	24	103.7	63	30
6 a.m.	101.8	54	18	101.2	54	18	101.7	52	21	103.7	66	33
7 a.m.	101.7	54	21	101.4	54	12	102.1	54	21	103.4	72	30
8 a.m.	101.8	48	21	101.5	54	18	102.2	48	24	103.1	63	42
9 a.m.	Inj. tuberculin S.			101.5	54	18	Inj. tuberculin S.			102.6	60	42
10 a.m.				101.0	48	15				101.8	54	33
11 a.m.				100.8	48	18				101.7	54	30
12 noon				100.3	54	18				101.2	54	36
1 p.m.				100.7	48	15				101.0	54	36
2 p.m.				101.0	54	18				101.2	48	32
3 p.m.				101.6	78	36				101.8	64	36
4 p.m.				102.0	72	36				102.0	66	42

Hour.	307						308					
	Feb. 1-2.			Feb. 2-3.			Feb. 1-2.			Feb. 2-3.		
	Before injection.			After injection.			Before injection.			After injection.		
	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.
9 a.m.	101.0	.....	.....	101.9	54	27	101.8	.....	.....	101.6	48	24
10 a.m.	101.4	.....	.....	101.4	45	24	101.3	.....	.....	101.4	48	21
11 a.m.	101.2	48	12	101.7	42	18	101.3	48	14	102.0	39	15
12 noon	101.2	54	18	101.7	48	18	101.2	48	14	101.1	42	18
* 1 p.m.	101.4	50	18	101.0	45	15	101.0	44	18	101.1	42	15
2 p.m.	101.5	48	18	101.3	51	18	101.2	42	16	101.1	42	15
3 p.m.	102.2	66	32	102.0	48	21	102.2	60	30	102.0	48	21
4 p.m.	102.4	72	36	102.4	78	36	102.3	66	30	102.7	60	24
5 p.m.	101.8	54	30	103.0	66	24	102.2	54	30	102.6	60	24
6 p.m.	101.4	54	30	104.2	60	18	101.8	48	24	104.0	54	21
7 p.m.	101.4	50	22	105.6	72	36	101.6	48	24	104.6	52	21
8 p.m.	100.7	54	30	106.6	72	24	101.6	44	22	104.6	54	21
9 p.m.	101.0	50	30	107.6	84	27	101.1	48	20	104.4	60	24
10 p.m.	101.4	48	30	107.2	90	30	101.8	48	20	104.2	54	24
11 p.m.	101.0	50	27	107.0	81	36	101.8	50	24	104.2	48	26
12 midnight	101.5	54	30	107.0	75	27	101.3	54	24	103.6	48	24
1 a.m.	101.4	48	26	106.7	78	36	101.8	48	24	102.9	54	21
2 a.m.	101.4	54	30	106.2	66	30	101.8	48	21	103.5	66	24
3 a.m.	101.4	54	27	106.6	72	42	101.4	48	24	102.0	48	36
4 a.m.	100.8	48	24	105.8	68	30	101.4	48	24	102.5	54	33
5 a.m.	101.8	54	24	105.6	66	42	101.7	54	30	101.9	60	34
6 a.m.	101.8	54	18	104.6	60	27	101.6	40	24	101.5	45	24
7 a.m.	102.2	48	18	104.8	64	30	101.6	45	21	101.0	48	20
8 a.m.	102.2	48	18	103.5	66	39	102.0	48	21	101.0	48	20
9 a.m.	Inj. tuberculin S.			103.6	66	36	Inj. tuberculin S.			101.1	48	21
10 a.m.				102.4	60	39				101.0	48	21
11 a.m.				101.8	54	24				101.2	48	21
12 noon				101.2	54	24				101.0	60	21
1 p.m.				101.4	54	30				100.7	42	21
2 p.m.				101.4	54	24				101.0	48	21
3 p.m.				102.2	66	36				102.0	60	21
4 p.m.				102.4	60	36				101.8	60	21

* Given a preliminary tuberculin test December 7, 1892.

Temperature as taken before and after the injection of tuberculin—Continued.

Hour.	309						310					
	Feb. 1-2. Before injection.			Feb. 2-3. After injection.			Feb. 1-2. Before injection.			Feb. 2-3. After injection.		
	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.
9 a. m.	100.4			101.0	42	18	100.0			102.4	70	2
10 a. m.	100.0			101.5	48	18	100.4			102.3	60	24
11 a. m.	100.4	42	12	101.5	45	21	100.8	44	14	102.3	54	18
12 noon	101.0	42	12	101.0	42	15	100.8	42	14	102.0	60	15
1 p. m.	101.0	48	12	101.2	36	15	101.2	54	15	102.2	60	15
2 p. m.	101.0	42	12	101.2	45	15	101.2	48	15	102.4	54	15
3 p. m.	100.8	66	30	101.5	42	18	102.0	72	28	102.4	60	18
4 p. m.	101.7	66	30	102.3	66	30	102.2	75	28	104.1	78	24
5 p. m.	102.4	56	30	102.2	60	27	102.0	72	28	104.1	112	24
6 p. m.	102.0	56	24	103.0	60	30	101.5	60	28	105.8	90	21
7 p. m.	101.8	48	24	104.6	54	15	101.6	66	24	105.2	54	18
8 p. m.	101.8	48	20	104.8	60	21	101.7	66	24	105.6	75	24
9 p. m.	101.4	42	24	104.8	72	30	101.4	66	24	104.8	78	21
10 p. m.	101.8	42	30	103.8	63	24	101.6	66	24	104.2	78	24
11 p. m.	101.6	48	24	104.2	48	24	101.6	60	20	104.0	96	24
12 midnight	101.8	42	24	104.0	54	21	101.8	54	26	103.8	78	27
1 a. m.	102.0	48	21	104.2	48	21	101.3	70	24	103.5	78	24
2 a. m.	101.7	60	27	103.6	60	27	102.0	60	24	103.2	66	18
3 a. m.	102.3	54	24	104.0	54	30	102.0	66	32	103.7	63	21
4 a. m.	101.8	54	24	103.1	54	24	101.8	66	24	103.1	60	21
5 a. m.	102.2	48	20	103.6	60	22	101.4	62	24	102.8	78	24
6 a. m.	102.2	48	18	103.0	78	21	102.0	60	21	102.2	72	21
7 a. m.	102.2	48	24	102.5	60	21						
8 a. m.	101.2	48	18	102.0	51	18	102.8	72	24	101.8	66	20
9 a. m.	Inj. tuberculin S.			101.8	48	24	Inj. tuberculin S.			100.4	54	15
10 a. m.				101.3	48	18						
11 a. m.				101.0	42	21				100.6	60	18
12 noon				101.4	42	24				100.4	60	18
1 p. m.				100.8	48	21						
2 p. m.				101.0	48	21						
3 p. m.				101.8	72	30						
4 p. m.				102.0	66	36						
311*												
Hour.	Mar. 15-16. Before injection.			Mar. 16-17. After injection.			Mar. 15-16. Before injection.			Mar. 16-17. After injection.		
	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.
9 a. m.	100.0	48	18	101.0	42	15	100.0	48	12	101.8	54	21
10 a. m.	100.2	48	18	101.0	42	18	99.8	48	15	101.7	60	21
11 a. m.	100.2	48	15	100.2	40	18	100.4	57	18	100.4	60	18
12 noon	100.2	51	18	100.4	40	18	100.4	54	18	100.4	60	15
1 p. m.	100.2	48	18	100.4	42	15	101.2	54	18	101.2	60	18
2 p. m.	100.4	48	18	100.4	48	18	101.8	72	21	102.2	60	21
3 p. m.	101.0	66	24	100.4	66	24	102.6	78	36	103.4	66	30
4 p. m.	102.0	60	24	101.1	66	24	103.0	69	30	104.2	66	30
5 p. m.	102.4	54	24	102.8	84	21	102.4	66	27	103.8	84	33
6 p. m.	101.8	48	21	104.0	60	18	102.0	60	27	105.2	80	30
7 p. m.	101.5	44	20	104.4	60	20	101.8	60	24	104.8	80	24
8 p. m.	101.6	48	20	105.0	66	27	101.5	56	30	104.3	68	30
9 p. m.	101.2	54	24	106.0	72	24	101.4	60	24	104.2	80	30
10 p. m.	101.4	48	21	106.2	72	21	101.6	60	24	103.8	72	24
11 p. m.	101.5	60	20	106.6	63	26	101.5	56	28	103.8	72	24
12 midnight	100.6	56	24	106.3	72	24	100.8	68	24	104.7	78	24
1 a. m.	100.4	60	24	106.2	60	24	101.6	56	20	104.6	78	24
2 a. m.	100.6	56	20	105.4	66	27	101.8	66	24	104.8	72	33
3 a. m.	100.8	60	24	105.1	63	21	101.8	56	18	104.8	78	21
4 a. m.	100.8	44	24	104.2	68	21	101.6	66	21	104.8	78	21
5 a. m.	101.0	44	24	104.6	60	20	102.0	60	20	104.8	66	22
6 a. m.	100.6	48	18	104.6	60	21	102.2	60	20	104.6	84	21
8 a. m.	101.0	44	18	103.0	54	21	102.4	52	20	104.2	84	21
9 a. m.	Inj. tuberculin S.						Inj. tuberculin S.					
10 a. m.				101.4	60	18				103.0	76	20
12 noon				101.2	66	18				102.8	72	24
1 p. m.				100.8	60	20				102.8	72	20

* Given a preliminary tuberculin test December 7, 1892.

Temperature as taken before and after the injection of tuberculin—Continued.

Hour.	313						314*					
	Mar. 15-16. Before injection.			Mar. 16-17. After injection.			Mar. 15-16. Before injection.			Mar. 16-17. After injection.		
	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.
9 a. m.	99.6	54	18	101.8	60	24	99.0	60	14	102.0	54	21
10 a. m.	99.4	48	18	101.8	60	21	99.0	60	14	102.0	66	24
11 a. m.	100.0	60	18	100.6	60	18	99.8	48	18	101.2	66	18
12 noon	100.4	54	18	100.8	60	18	100.5	54	21	100.8	66	18
1 p. m.	100.4	54	21	100.8	60	18	101.0	54	21	101.3	54	21
2 p. m.	101.0	63	21	101.4	60	21	101.2	60	21	102.0	72	24
3 p. m.	102.0	72	33	102.2	72	30	102.0	78	33	102.4	72	24
4 p. m.	102.3	72	30	102.6	84	30	102.2	66	33	103.4	72	30
5 p. m.	102.1	66	30	103.1	66	21	102.0	66	30	103.0	60	21
6 p. m.	102.0	72	30	103.1	66	24	102.2	69	36	104.3	68	24
7 p. m.	102.2	60	24	104.6	72	24	102.0	66	28	105.4	72	24
8 p. m.	101.6	68	28	105.2	72	24	102.0	60	32	105.8	84	24
9 p. m.	102.0	68	24	106.0	72	24	101.8	56	28	107.0	72	30
10 p. m.	101.5	60	20	106.4	72	27	101.4	60	24	106.8	75	33
11 p. m.	101.8	64	30	106.6	75	26	101.5	60	24	106.6	72	27
12 midnight	101.4	64	24	106.0	84	30	102.0	56	20	106.0	72	24
1 a. m.	101.3	64	24	106.4	72	24	101.5	56	24	105.6	72	27
2 a. m.	101.4	60	20	106.0	84	30	101.6	64	24	104.6	72	24
3 a. m.	101.0	72	24	105.8	84	30	101.5	72	18	105.0	78	30
4 a. m.	101.2	60	18	106.2	69	33	101.2	66	24	103.0	48	18
5 a. m.	101.5	64	24	105.0	78	24	102.0	60	20	103.0	75	27
6 a. m.	101.4	60	18	105.2	66	24	102.2	66	24	102.6	60	18
7 a. m.	101.8	56	18	105.6	63	27	102.6	52	20	102.0	66	24
8 a. m.	Inj. tuberculin S.			Inj. tuberculin S.			Inj. tuberculin S.			Inj. tuberculin S.		
10 a. m.				103.2	66	20				100.8	64	24
12 noon				102.6	68	24				100.5	56	18
1 p. m.				102.0	60	24				100.8	64	18
				*								

Hour.	315						316					
	Mar. 15-16. Before injection.			Mar. 16-17. After injection.			Mar. 15-16. Before injection.			Mar. 16-17. After injection.		
	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.	Tempera- ture.	Pulse.	Respira- tion.
9 a. m.	98.6	54	18	101.8	57	24	101.3	60	12	101.4	60	16
10 a. m.	98.8	48	15	101.6	57	24	101.4	60	18	101.4	60	16
11 a. m.	99.4	54	18	101.2	57	24	101.6	60	18	100.6	60	18
12 noon	99.8	54	18	100.8	57	21	101.8	60	18	101.0	60	21
1 p. m.	100.0	54	18	101.2	48	24	101.6	60	18	101.3	54	18
2 p. m.	101.2	60	18	101.6	60	30	101.6	66	24	101.4	63	21
3 p. m.	102.0	66	30	102.6	84	30	102.2	78	24	101.6	78	30
4 p. m.	102.2	60	27	102.6	60	27	102.6	72	27	102.4	78	27
5 p. m.	102.4	60	30	102.2	60	24	101.4	78	24	102.0	78	30
6 p. m.	102.0	60	30	103.8	76	21	101.5	72	27	102.6	76	28
7 p. m.	101.6	60	28	104.5	60	24	101.4	66	24	103.2	80	24
8 p. m.	101.8	64	32	105.6	84	24	101.6	60	24	103.7	72	20
9 p. m.	102.0	56	24	106.8	75	27	101.4	64	24	105.3	72	20
10 p. m.	101.8	60	24	106.2	84	24	101.2	60	20	105.9	72	24
11 p. m.	102.0	60	20	106.2	72	24	101.5	60	24	106.2	84	24
12 midnight	101.2	56	28	105.6	81	28	100.8	64	30	106.0	72	33
1 a. m.	101.6	56	24	105.8	66	21	100.8	60	20	105.4	72	30
2 a. m.	101.5	56	24	105.6	78	27	101.3	64	18	105.2	72	30
3 a. m.	101.8	60	24	105.6	72	21	101.0	56	20	105.0	88	33
4 a. m.	101.8	57	24	105.0	60	20	100.8	56	24	104.8	84	24
5 a. m.	102.0	60	20	104.0	72	24	101.8	64	18	103.2	72	30
6 a. m.	101.8	60	20	104.0	72	22	101.5	60	18	102.8	72	27
7 a. m.	101.8	56	20	103.5	60	21	101.4	64	16	102.7	78	24
8 a. m.	Inj. tuberculin S.			Inj. tuberculin S.			Inj. tuberculin S.			Inj. tuberculin S.		
10 a. m.				102.2	56	24				101.8	72	18
12 noon				101.8	56	24				102.5	66	18
1 p. m.				101.6	56	24				102.3	64	24

* Given a preliminary tuberculin test December 7, 1892.

Temperature as taken before and after the injection of tuberculin—Continued.

Hour.	317						318					
	Mar. 15-16. Before injection.			Mar. 16-17. After injection.			Mar. 15-16. Before injection.			Mar. 16-17. After injection.		
	Temperature.	Pulse.	Respiration.	Temperature.	Pulse.	Respiration.	Temperature.	Pulse.	Respiration.	Temperature.	Pulse.	Respiration.
9 a.m.	101.0	42	12	101.7	48	18	98.8	48	15	102.5	66	66
10 a.m.	100.0	42	15	101.6	45	15	98.6	60	15	102.2	60	60
11 a.m.	100.8	42	15	101.8	39	15	99.0	60	15	101.6	60	60
12 noon	100.8	42	15	101.4	39	15	99.4	54	15	101.4	54	54
1 p.m.	100.8	39	12	101.4	39	12	100.0	54	18	101.6	54	54
2 p.m.	101.3	42	15	102.0	51	15	100.2	54	18	102.0	66	66
3 p.m.	102.0	54	24	102.0	66	27	101.4	72	24	101.0	72	72
4 p.m.	102.6	60	24	102.6	72	24	102.7	72	24	105.2	72	72
5 p.m.	103.0	66	24	102.0	72	21	102.8	72	27	105.2	78	78
6 p.m.	102.4	60	20	102.2	66	24	103.0	60	27	106.6	80	80
7 p.m.	102.0	44	20	103.4	56	16	102.4	66	24	107.4	76	76
8 p.m.	102.0	48	24	103.5	64	18	102.0	60	24	107.2	72	72
9 p.m.	102.0	48	20	104.5	66	18	102.2	60	24	107.0	72	72
10 p.m.	102.2	44	24	105.4	69	18	102.0	56	18	106.4	78	78
11 p.m.	102.0	56	24	105.4	66	21	102.0	60	20	106.4	72	72
12 midnight	101.8	48	16	105.6	60	18	101.6	64	20	105.4	84	84
1 a.m.	102.0	60	24	105.4	78	18	101.4	56	24	106.2	78	78
2 a.m.	101.7	44	20	105.6	78	22	102.2	52	18	106.0	84	84
3 a.m.	101.8	56	18	105.8	72	21	101.6	56	18	105.4	84	84
4 a.m.	102.0	54	18	104.8	75	22	101.5	60	24	105.0	84	84
5 a.m.	102.0	40	18	104.8	66	18	102.0	60	18	105.0	78	78
6 a.m.	101.8	44	18	104.4	60	21	102.2	72	20	104.8	78	78
8 a.m.	101.8	44	15	104.2	51	21	103.2	60	18	104.2	72	72
9 a.m.	Inj. tuberculin S.						Inj. tuberculin S.					
10 a.m.				103.0	60	18				103.2	64	64
12 noon				102.2	52	18				103.2	66	66
1 p.m.				102.4	60	18				102.6	72	72

Hour.	319						320					
	Mar. 15-16. Before injection.			Mar. 16-17. After injection.			Mar. 15-16. Before injection.			Mar. 16-17. After injection.		
	Temperature.	Pulse.	Respiration.	Temperature.	Pulse.	Respiration.	Temperature.	Pulse.	Respiration.	Temperature.	Pulse.	Respiration.
9 a.m.	99.8	48	18	102.0	60	15	98.8	60	12	101.8	44	44
10 a.m.	99.5	66	18	102.0	57	15	99.4	66	12	101.2	51	51
11 a.m.	99.0	60	15	101.0	60	15	99.0	54	12	100.0	48	48
12 noon	100.8	54	15	100.8	54	15	99.4	54	12	99.8	48	48
1 p.m.	101.4	54	15	101.0	48	15	100.4	54	12	99.9	51	51
2 p.m.	101.6	48	15	101.3	57	18	100.3	60	15	100.2	57	57
3 p.m.	102.0	60	24	102.2	60	21	100.8	78	30	101.0	69	69
4 p.m.	103.0	66	24	102.7	60	21	102.0	78	24	102.0	72	72
5 p.m.	103.3	66	24	101.0	66	21	102.6	63	24	101.0	66	66
6 p.m.	103.1	57	18	101.5	60	20	102.2	69	15	101.6	66	66
7 p.m.	102.2	60	20	102.3	60	16	102.0	60	18	102.0	60	60
8 p.m.	103.0	56	16	102.5	54	14	101.5	52	16	102.5	72	72
9 p.m.	103.1	52	24	102.8	63	15	101.5	60	24	103.2	60	60
10 p.m.	102.5	60	20	102.6	63	18	101.6	60	24	103.6	60	60
11 p.m.	102.5	60	20	102.8	54	18	101.5	60	20	104.2	66	66
12 midnight	102.4	56	16	101.8	66	21	101.4	56	16	104.2	66	66
1 a.m.	101.8	60	20	101.8	54	15	101.2	64	16	103.6	57	57
2 a.m.	102.0	64	18	102.2	57	18	101.0	56	24	103.2	69	69
3 a.m.	102.0	60	18	101.6	54	15	101.2	60	24	102.8	66	66
4 a.m.	102.2	54	24	102.0	72	18	101.5	56	18	102.6	72	72
5 a.m.	101.8	56	24	101.8	60	15	101.4	60	15	102.2	66	66
6 a.m.	101.8	60	18	101.5	60	15	101.5	66	24	102.5	66	66
8 a.m.	102.5	56	16	101.6	54	18	101.6	48	18	101.8	66	66
9 a.m.	Inj. tuberculin S.						Inj. tuberculin S.					
10 a.m.				102.0	48	16				101.2	52	52
12 noon				101.8	54	18				101.5	48	48
1 p.m.				101.8	56	18				101.0	66	66

Temperature as taken before and after the injection of tuberculin—Continued.

Hour.	321						322					
	Mar. 15-16. Before injection.			Mar. 16-17. After injection.			Mar. 15-16. Before injection.			Mar. 16-17. After injection.		
	Temperature.	Pulse.	Respiration.	Temperature.	Pulse.	Respiration.	Temperature.	Pulse.	Respiration.	Temperature.	Pulse.	Respiration.
9 a. m.	100.8	48	15	101.8	44	18	99.6	40	42	102.2	48	20
10 a. m.	100.6	51	15	101.6	44	12	99.6	42	12	102.0	48	15
11 a. m.	100.6	48	15	101.2	54	12	100.0	42	12	99.1	54	18
12 noon	100.4	48	15	100.9	51	12	100.2	42	12	99.0	51	15
1 p. m.	100.4	42	12	100.8	51	12	100.5	42	12	99.6	42	15
2 p. m.	100.8	54	15	101.2	48	15	100.4	48	18	99.8	54	18
3 p. m.	101.4	60	27	101.2	66	24	101.6	54	24	101.0	66	21
4 p. m.	101.8	60	24	102.2	54	24	102.4	54	24	101.2	54	21
5 p. m.	102.0	57	24	101.2	54	18	102.2	54	24	101.0	60	21
6 p. m.	102.2	54	18	101.6	52	15	102.3	54	21	100.8	60	20
7 p. m.	102.0	54	18	101.8	48	16	102.4	54	21	101.4	60	15
8 p. m.	101.8	64	20	101.6	60	12	102.0	52	20	101.8	52	12
9 p. m.	102.0	60	20	102.2	60	18	102.5	56	24	102.2	68	20
10 p. m.	101.8	60	24	103.0	60	18	102.0	48	24	102.8	54	18
11 p. m.	102.0	60	20	103.4	48	18	102.0	56	20	103.0	54	18
12 midnight	102.0	60	12	103.3	57	18	101.8	48	16	102.4	54	18
1 a. m.	101.6	56	24	103.2	57	18	102.2	52	16	102.0	57	18
2 a. m.	101.2	68	18	103.0	45	21	101.8	48	16	103.0	54	15
3 a. m.	101.8	60	18	103.6	48	18	101.8	56	18	103.0	58	15
4 a. m.	101.4	52	24	102.4	51	18	102.2	54	18	102.6	48	12
5 a. m.	100.8	60	18	101.8	54	18	102.0	60	18	102.5	54	12
6 a. m.	101.6	56	20	102.0	54	18	102.0	48	18	102.4	54	15
8 a. m.	101.5	44	20	101.8	48	12	102.2	48	12	102.8	54	12
1 a. m.	Inj. tuberculin S.						Inj. tuberculin S.					
10 a. m.				101.4	48	18				101.9	52	12
12 noon				101.6	60	18				101.8	48	15
1 p. m.				102.0	48	18				101.2	56	18

Hour.	323						324					
	Mar. 15-16. Before injection.			Mar. 16-17. After injection.			Mar. 15-16. Before injection.			Mar. 16-17. After injection.		
	Temperature.	Pulse.	Respiration.	Temperature.	Pulse.	Respiration.	Temperature.	Pulse.	Respiration.	Temperature.	Pulse.	Respiration.
9 a. m.	99.7	50	15	102.0	57	18	101.0	72	21	102.6	68	18
10 a. m.	100.0	48	15	102.0	60	18	100.5	66	18	102.8	66	24
11 a. m.	100.2	54	18	100.4	60	18	100.8	72	18	102.6	66	21
12 noon	100.4	51	15	100.4	57	15	101.2	72	18	102.5	66	21
1 p. m.	101.0	48	15	101.4	57	18	101.5	66	18	103.4	66	24
2 p. m.	101.6	60	18	101.2	60	18	101.7	72	24	103.4	72	24
3 p. m.	101.8	72	39	101.6	66	24	102.9	84	33	103.8	84	30
4 p. m.	102.9	72	27	102.2	66	24	103.2	81	27	105.6	66	33
5 p. m.	103.5	72	27	102.5	66	24	104.0	78	30	105.0	78	24
6 p. m.	103.4	60	27	103.5	64	20	103.8	72	24	104.8	72	24
7 p. m.	102.6	60	24	104.2	72	20	103.6	72	30	104.6	80	30
8 p. m.	102.5	64	20	104.8	72	18	103.2	66	28	105.0	72	28
9 p. m.	102.4	64	28	105.8	60	18	103.0	64	24	105.6	80	30
10 p. m.	102.2	56	24	105.8	75	21	103.5	72	32	105.6	90	24
11 p. m.	102.2	60	20	106.4	78	21	103.2	64	24	105.4	90	24
12 midnight	102.0	60	18	106.2	84	24	103.0	60	20	105.4	90	30
1 a. m.	101.8	60	20	105.6	78	24	103.4	72	20	105.6	84	30
2 a. m.	101.8	60	18	106.0	72	24	103.0	68	24	105.6	84	30
3 a. m.	101.6	64	20	105.4	78	18	102.5	80	24	105.8	84	30
4 a. m.	101.4	60	24	105.2	87	30	103.2	72	24	105.8	84	30
5 a. m.	102.0	60	18	104.6	72	30	103.0	80	24	105.6	84	30
6 a. m.	102.0	56	24	103.8	66	24	102.8	72	24	105.4	84	30
8 a. m.	102.0	56	24	102.8	66	24	102.8	72	18	105.6	84	30
9 a. m.	Inj. tuberculin S.						Inj. tuberculin S.					
10 a. m.				102.0	72	24				104.5		
12 noon				101.4	66	20				103.0		
1 p. m.				101.2	60	18				103.6		

Temperature as taken before and after the injection of tuberculin—Continued.

Hour.	325		326		327		328	
	Mar. 21. Before injection.	Mar. 22. After injection.	Mar. 21. Before injection.	Mar. 22. After injection.	Mar. 21. Before injection.	Mar. 22. After injection.	Mar. 21. Before injection.	Mar. 22. After injection.
7 a.m.		100.7		101.6		102.4		102.2
8 a.m.	101.8	101.2	102.2	101.9	103.2	102.4	100.2	102.6
9 a.m.	101.2	101.4	102.2	101.9	102.8	102.5	98.8	103.4
10 a.m.	100.5	100.0	100.6	101.4	102.5	102.5	99.5	102.6
11 a.m.	99.4	100.4	100.2	101.5	103.0	102.4	100.0	103.4
12 noon	100.2	100.4	100.8	101.5	102.6	102.2	99.5	104.2
1 p.m.	101.0	100.6	100.8	101.2	102.4	102.2	100.5	104.2
2 p.m.	101.2	101.0	101.6	102.0	102.2	102.2	101.4	103.4
3 p.m.	101.2	101.6	101.6	102.2	102.2	102.4	101.4	103.6
4 p.m.	101.6	101.8	102.0	102.8	102.2	103.4	101.8	103.6
5 p.m.		102.0		102.5		103.0		103.8
6 p.m.	101.4	101.6	101.5	102.4	102.0	102.4	101.8	103.0
7 p.m.	102.0	101.4	101.6	102.0	102.4	102.5	102.0	102.5
8 p.m.	101.8	101.0	102.0	101.8	102.6	102.2	101.8	102.0
9 p.m.	101.8	101.2	101.5	102.4	102.4	102.8	101.2	101.8
10 p.m.	101.8	101.4	101.6	101.8	102.6	102.6	101.0	102.0
11 p.m.	101.8		101.8		102.8		101.0	
12 midnight	Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin K.	
Hour.	329		330		331		332	
	Mar. 21. Before injection.	Mar. 22. After injection.	Mar. 21. Before injection.	Mar. 22. After injection.	Mar. 21. Before injection.	Mar. 22. After injection.	Mar. 21. Before injection.	Mar. 22. After injection.
7 a.m.		103.5		101.8		102.0		104.9
8 a.m.	101.0	107.2	100.6	102.2	100.4	102.4	100.3	105.8
9 a.m.	100.6	107.5	100.8	102.7	99.8	103.2	99.2	106.4
10 a.m.	100.8	105.6	100.0	103.2	99.5	104.4	99.5	105.8
11 a.m.	101.0	106.0	101.0	105.0	100.6	104.9	101.0	106.4
12 noon	100.2	106.0	100.8	105.8	100.2	105.6	101.2	107.1
1 p.m.	101.4	106.0	100.4	105.8	101.1	105.8	101.4	106.6
2 p.m.	101.2	105.4	101.6	105.8	101.0	105.8	101.9	106.2
3 p.m.	102.2	105.8	101.8	105.6	101.2	105.6	102.4	105.8
4 p.m.	102.8	105.4	102.0	105.5	101.6	105.8	102.3	106.3
5 p.m.		106.0		105.4		106.2		106.2
6 p.m.	103.0	105.0	101.8	104.4	102.0	104.8	102.4	105.8
7 p.m.	102.8	105.4	102.2	103.6	101.8	105.0	102.4	106.8
8 p.m.	102.6	105.5	102.0	103.0	101.8	105.0	102.0	106.5
9 p.m.	102.4	105.6	101.2	104.2	101.8	105.0	101.8	106.2
10 p.m.	102.6	105.4	101.5	104.6	101.4	105.6	101.8	105.8
11 p.m.	102.4		101.2		101.2		101.9	
12 midnight	Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin K.	
Hour.	333		334		335		336	
	Mar. 21. Before injection.	Mar. 22. After injection.	Mar. 21. Before injection.	Mar. 22. After injection.	Mar. 21. Before injection.	Mar. 22. After injection.	Mar. 21. Before injection.	Mar. 22. After injection.
7 a.m.		106.0		102.2		103.0		101.7
8 a.m.	101.2	106.6	102.2	102.6	100.5	104.8	101.5	105.6
9 a.m.	101.2	106.9	101.4	102.5	100.6	106.2	101.2	103.6
10 a.m.	101.3	105.0	101.5	101.5	101.8	105.2	101.0	103.4
11 a.m.	101.2	106.0	100.8	102.0	101.0	106.4	101.0	101.2
12 noon	101.2	106.6	100.0	102.6	100.8	106.0	100.2	104.2
1 p.m.	101.0	105.8	101.4	102.5	101.2	106.6	100.6	104.3
2 p.m.	101.2	105.0	101.6	102.5	101.1	106.6	101.4	105.4
3 p.m.	101.6	104.0	102.4	102.9	101.6	106.0	102.0	105.6
4 p.m.	101.6	103.8	102.2	102.6	101.5	106.8	102.5	105.6
5 p.m.		102.8		102.5		107.8		106.0
6 p.m.	101.6	103.0	101.8	101.0	102.0	106.5	102.5	104.6
7 p.m.	102.0	103.4	101.8	101.0	102.0	107.2	102.6	104.6
8 p.m.	101.6	103.4	101.2	102.2	102.2	107.8	101.6	104.6
9 p.m.	101.7	103.0	101.6	101.6	102.0	107.2	101.5	104.0
10 p.m.	101.8	102.8	101.4	101.2	102.0	107.0	102.2	104.2
11 p.m.	101.9		101.5		101.8		102.2	
12 midnight	Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin K.	

Temperature as taken before and after the injection of tuberculin—Continued.

Hour.	337		338		339		340	
	Mar. 21. Before injection.	Mar. 22. After injection.	Mar. 27. Before injection.	Mar. 28. After injection.	Mar. 27. Before injection.	Mar. 28. After injection.	Mar. 27. Before injection.	Mar. 28. After injection.
7 a. m.		102.2		103.8		102.4		103.0
8 a. m.	101.0	102.2	102.2	103.0	99.8	102.0	99.9	102.5
9 a. m.	101.0	103.0	102.2	103.3	100.8	102.4	99.9	103.2
10 a. m.	100.5	103.0	103.0	103.6	101.2	103.4	100.6	104.0
11 a. m.	99.8	103.6	103.2	103.6	101.2	103.6	101.2	104.0
12 noon	99.8	105.0	103.3	103.2	101.0	103.4	101.0	103.6
1 p. m.	100.4	105.0	103.2	103.2	100.8	103.2	101.0	103.6
2 p. m.	101.2	105.5	103.6	103.2	100.8	103.0	101.4	102.8
3 p. m.	101.2	105.2	103.6	103.4	101.3	103.0	101.3	102.6
4 p. m.	101.4	105.5	103.2	103.6	101.4	102.8	101.6	102.6
5 p. m.		105.2	103.2	103.0	102.0	103.0	101.6	102.6
6 p. m.	102.2	103.7	102.6	103.2	101.3	102.8	101.2	102.4
7 p. m.	101.8	104.0	102.4	102.8	101.4	102.8	101.0	102.0
8 p. m.	102.6	104.2	101.6	101.8	101.2	103.2	100.8	102.2
9 p. m.	102.0	104.0	101.6	101.8	101.2	103.2	101.0	102.2
10 p. m.	101.8	103.8	101.7	101.6	101.0	102.5	100.8	102.0
11 p. m.	101.6		101.6	101.4	101.0	102.2	101.0	101.8
12 midnight	Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin K.	
Hour.	341		342		343		344	
	Mar. 27. Before injection.	Mar. 28. After injection.	Mar. 27. Before injection.	Mar. 28. After injection.	Mar. 27. Before injection.	Mar. 28. After injection.	Mar. 27. Before injection.	Mar. 28. After injection.
7 a. m.		103.7		104.2		106.2		101.6
8 a. m.	101.0	103.0	99.6	104.8	100.8	106.0	99.8	101.7
9 a. m.	101.8	103.8	100.2	105.3	101.3	106.5	100.0	102.4
10 a. m.	102.0	104.0	100.4	105.6	101.0	107.0	100.4	104.0
11 a. m.	102.0	105.0	100.8	105.6	101.2	106.5	100.8	104.8
12 noon	101.8	104.7	100.6	106.0	101.0	106.2	100.6	105.2
1 p. m.	102.1	104.8	100.6	105.8	100.8	106.0	101.0	105.2
2 p. m.	102.0	104.0	101.0	105.0	101.0	105.0	100.8	104.1
3 p. m.	102.2	103.8	101.2	104.4	101.2	105.0	101.6	104.4
4 p. m.	102.4	104.4	101.5	105.2	101.6	105.2	101.7	105.1
5 p. m.	102.2	104.5	102.2	105.0	101.4	104.8	101.8	104.6
6 p. m.	102.6	104.2	102.0	104.5	101.2	104.5	101.5	104.2
7 p. m.	102.6	104.0	101.8	104.8	101.3	104.2	101.0	104.6
8 p. m.	102.8	104.2	101.7	104.0	101.2	103.6	101.5	103.2
9 p. m.	103.0	104.4	102.0	103.8	101.2	102.8	101.2	103.2
10 p. m.	102.5	104.4	101.6	103.2	101.2	102.8	101.6	102.5
11 p. m.	102.4	104.0	101.5	102.8	101.4	102.5	101.4	102.0
12 midnight	Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin K.	
Hour.	345		346		347		348	
	Mar. 27. Before injection.	Mar. 28. After injection.	Mar. 27. Before injection.	Mar. 28. After injection.	Apr. 12. Before injection.	Apr. 13. After injection.	Apr. 12. Before injection.	Apr. 13. After injection.
7 a. m.		102.0		101.3		102.6		101.8
8 a. m.	99.8	102.5	99.4	101.4	100.6	102.4	100.2	101.6
9 a. m.	100.2	102.8	99.4	101.8	101.0	104.2	100.4	102.7
10 a. m.	100.2	104.8	100.2	102.8	101.1	105.4	101.0	103.6
11 a. m.	100.8	105.3	100.2	104.9	101.3	105.6	101.0	104.8
12 noon	100.6	106.9	100.6	104.8	101.4	105.4	101.0	105.6
1 p. m.	100.6	106.0	100.6	104.6	101.5	105.8	101.4	105.6
2 p. m.	100.4	105.4	101.2	104.8	101.6	105.7	101.4	105.2
3 p. m.	101.2	105.2	101.4	104.8	101.6	105.6	102.0	105.2
4 p. m.	101.6	106.2	101.7	105.2	102.8	106.8	102.7	106.0
5 p. m.	101.6	106.0	101.8	105.0	102.6	106.7	102.4	106.2
6 p. m.	101.4	106.0	101.3	105.2	102.4	106.6	102.4	105.7
7 p. m.	101.4	106.2	101.0	106.4	102.0	106.0	102.0	105.5
8 p. m.	101.2	105.2	101.0	105.3	102.0	106.1	101.6	105.6
9 p. m.	100.8	105.2	101.0	104.8	101.6	106.2	101.6	105.8
10 p. m.	100.6	104.6	100.5	105.2	101.6	105.8	101.4	105.6
11 p. m.	101.0	104.2	101.0	104.5	101.3	105.8	101.6	105.2
12 midnight	Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin S.		Inj. tuberculin S.	

Temperature as taken before and after the injection of tuberculin—Continued.

Hour.	349		350		351		352	
	Apr. 12. Before injection.	Apr. 13. After injection.	Apr. 12. Before injection.	Apr. 13. After injection.	Apr. 12. Before injection.	Apr. 13. After injection.	Apr. 12. Before injection.	Apr. 13. After injection.
7 a. m.		104.8		101.4		103.8		103.0
8 a. m.	101.3	104.5	100.5	101.0	100.0	104.3	102.3	103.0
9 a. m.	101.8	106.0	100.6	103.4	101.2	105.4	102.6	104.9
10 a. m.	101.4	106.7	100.4	106.0	101.6	106.6	101.8	106.2
11 a. m.	101.8	106.5	100.6	105.4	101.6	106.4	101.4	106.2
12 noon	101.8	106.0	100.2	105.0	101.6	106.4	101.4	105.2
1 p. m.	101.6	106.2	100.6	105.0	101.2	106.2	101.6	105.2
2 p. m.	101.7	106.2	101.2	104.0	101.4	105.8	101.7	104.2
3 p. m.	102.2	105.6	101.6	104.8	101.0	105.8	102.4	104.4
4 p. m.	102.6	105.8	101.5	105.6	101.4	106.1	102.6	105.2
5 p. m.	102.2	106.0	101.6	105.6	102.6	106.4	102.8	105.3
6 p. m.	102.2	106.2	101.5	105.6	102.4	106.2	103.0	105.0
7 p. m.	102.0	105.8	101.2	105.0	102.2	106.7	102.8	104.5
8 p. m.	101.8	105.0	100.8	105.2	101.8	105.8	102.8	104.2
9 p. m.	101.8	104.2	100.8	105.4	101.7	105.8	102.2	104.2
10 p. m.	101.6	103.8	100.8	105.4	101.6	105.8	102.2	104.1
11 p. m.	101.6	103.5	101.0	105.2	101.6	105.5	102.2	104.4
12 midnight.	Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.	
Hour.	353		354		355		356	
	Apr. 12. Before injection.	Apr. 13. After injection.	May 1. Before injection.	May 2. After injection.	May 1. Before injection.	May 2. After injection.	May 1. Before injection.	May 2. After injection.
7 a. m.		102.2		102.8		101.8		101.5
8 a. m.	101.4	102.2		103.4		101.6		101.6
9 a. m.	102.2	101.8	101.8	103.2	100.5	101.8	100.4	101.6
10 a. m.	102.0	101.8	102.2	104.2	100.8	102.0	100.9	101.6
11 a. m.	102.0	102.6	101.8	105.4	101.0	103.2	100.8	102.0
12 noon	101.8	103.6		106.0		103.9		102.6
1 p. m.	101.6	103.4	101.5	105.6	101.6	104.8	100.8	102.9
2 p. m.	101.2	102.6	101.8	105.4	101.6	105.4	101.4	103.6
3 p. m.	101.6	103.0	101.8	104.8	101.2	104.8	101.8	103.2
4 p. m.	102.6	103.4	102.6	104.4	101.8	104.2	102.0	103.6
5 p. m.	102.2	103.8	103.4	104.8	102.8	104.3	102.0	104.0
6 p. m.	102.5	103.4	103.5		102.8		101.8	
7 p. m.	102.2	103.4	102.6	106.0	102.0	104.0	101.6	104.0
8 p. m.	102.0	102.4	102.2	105.6	101.6	103.6	101.2	103.7
9 p. m.	102.0	102.4	102.4	105.0	101.4	104.0	101.2	103.5
10 p. m.	101.8	102.2	102.0	104.5	101.2	103.2	101.0	103.2
11 p. m.	101.8	102.0	101.8	104.2	101.4	103.0	100.8	102.8
12 midnight.	Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.	
Hour.	357		358		359		360	
	May 1. Before injection.	May 2. After injection.	May 1. Before injection.	May 2. After injection.	May 1. Before injection.	May 2. After injection.	May 1. Before injection.	May 2. After injection.
7 a. m.		102.4		101.6		104.4		101.2
8 a. m.		102.2		101.6		104.8		101.2
9 a. m.	101.8	102.4	101.4	101.2	101.2	106.0	101.8	100.6
10 a. m.	101.5	102.6	101.2	101.2	101.3	106.8	101.5	100.7
11 a. m.	101.7	102.8	101.2	101.6	101.5	106.9	101.4	100.6
12 noon		102.9		102.4		107.0		100.6
1 p. m.	101.4	102.8	101.3	102.8	101.4	107.2	101.4	101.0
2 p. m.	101.8	103.0	101.6	103.8	101.3	107.3	101.9	101.3
3 p. m.	101.8	102.8	101.2	103.6	102.5	105.4	101.5	101.4
4 p. m.	102.2	102.6	101.8	104.6	102.8	104.8	102.4	102.2
5 p. m.	102.6	103.0	102.0	105.0	102.8	105.2	102.2	102.4
6 p. m.	102.8		102.0		103.2		102.4	
7 p. m.	101.4	102.2	101.2	105.6	102.6	106.2	101.6	102.8
8 p. m.	101.6	102.0	100.8	105.4	102.2	106.0	101.5	102.4
9 p. m.	101.6	101.2	100.8	104.6	102.4	104.7	101.2	102.2
10 p. m.	101.4	101.8	100.8	104.0	102.4	104.0	101.2	102.0
11 p. m.	101.4	101.5	100.6	103.8	102.2	103.6	101.0	101.8
12 midnight.	Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.	

Temperature as taken before and after the injection of tuberculin—Continued.

Hour.	361		362		363		301	
	May 1. Before injection.	May 2. After injection.	May 1. Before injection.	May 2. After injection.	May 1. Before injection.	May 2. After injection.	Mar. 21. Before injection.	Mar. 22. After injection.
7 a.m.		101.6		102.6		102.0		104.2
8 a.m.		101.9		103.4		102.4	100.4	104.8
9 a.m.	101.6	102.4	101.2	104.0	101.9	101.4	100.5	105.7
10 a.m.	101.3	103.6	101.4	104.4	101.2	102.4	99.8	104.6
11 a.m.	101.6	104.4	101.2	104.8	101.3	103.8	99.6	104.9
12 noon		105.2		104.2		104.4	100.8	105.8
1 p.m.	101.2	105.0	101.2	104.0	101.3	105.4	101.4	105.6
2 p.m.	101.2	105.0	102.0	103.6	101.6	106.0	101.2	105.6
3 p.m.	101.8	104.8	101.8	103.0	101.5	105.0	102.0	105.6
4 p.m.	102.4	104.2	102.2	103.4	102.4	105.0	102.7	106.5
5 p.m.	102.6	105.2	102.8	103.4	102.8	105.8		105.2
6 p.m.	102.6		102.2		103.2		102.7	104.8
7 p.m.	101.6	105.8	101.2	103.8	101.8	105.2	102.0	105.0
8 p.m.	101.7	105.5	101.2	103.6	101.6	104.0	101.8	104.5
9 p.m.	101.6	104.5	101.5	102.4	101.6	103.4	101.9	103.8
10 p.m.	101.4	103.7	101.4	103.0	101.6	103.2	101.8	103.6
11 p.m.	101.4	103.2	101.2	102.6	101.8	103.0	101.8	
12 midnight	Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin K.	
Hour.	302		305		307		308	
	Mar. 21. Before injection.	Mar. 22. After injection.	Mar. 21. Before injection.	Mar. 22. After injection.	Mar. 21. Before injection.	Mar. 22. After injection.	Mar. 21. Before injection.	Mar. 22. After injection.
7 a.m.		104.9		102.8		103.5		102.7
8 a.m.	99.8	105.2	99.6	102.4	102.0	103.8	101.0	102.8
9 a.m.	100.0	105.8	99.4	102.0	102.0	104.2	101.0	103.0
11 a.m.	100.5	105.2	100.2	101.2	101.8	103.6	100.6	102.8
10 a.m.	100.2	105.8	100.2	101.0	102.0	104.2	101.0	102.7
12 noon	100.6	106.8	100.4	101.0	101.6	105.4	101.0	102.8
1 p.m.	101.0	106.5	101.0	101.3	101.7	105.8	101.4	102.4
2 p.m.	101.0	106.2	103.8	101.2	102.6	106.3	101.2	102.6
3 p.m.	101.6	106.0	101.2	102.0	102.0	106.0	102.0	102.8
4 p.m.	102.0	106.8	101.7	103.0	103.0	106.2	102.0	102.8
5 p.m.		106.0		102.4		105.0		102.5
6 p.m.	102.2	105.4	102.0	102.5	102.2	104.0	102.0	102.2
7 p.m.	101.8	105.4	101.8	101.8	102.5	103.8	102.2	102.0
8 p.m.	101.7	105.0	101.5	101.8	102.6	103.8	101.8	101.5
9 p.m.	101.3	104.2	101.4	101.4	102.4	103.0	101.7	101.0
10 p.m.	101.6	104.2	101.4	101.8	102.2	103.0	101.8	101.3
11 p.m.	101.6		101.0		102.0		101.9	
12 midnight	Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin K.	
Hour.	309		310		312		313	
	Mar. 21. Before injection.	Mar. 22. After injection.	Mar. 21. Before injection.	Mar. 22. After injection.	Mar. 27. Before injection.	Mar. 28. After injection.	Mar. 27. Before injection.	Mar. 28. After injection.
7 a.m.		102.2		103.7		102.8		102.5
8 a.m.	101.5	102.4	102.2	103.8	100.8	102.8	100.6	102.4
9 a.m.	100.8	102.3	101.8	104.0	100.9	103.0	101.5	102.4
10 a.m.	101.0	100.6	101.4	102.0	100.9	104.4	101.5	103.2
11 a.m.	100.8	100.7	101.2	102.2	101.2	104.8	101.8	103.8
12 noon	101.2	101.4	101.2	102.8	100.8	104.7	101.8	104.0
1 p.m.	101.2	101.6	101.6	102.8	101.0	104.2	102.0	104.4
2 p.m.	101.4	102.0	101.8	103.5	101.2	104.0	102.2	104.0
3 p.m.	102.0	102.4	102.2	104.0	101.7	103.4	102.0	103.5
4 p.m.	102.4	104.0	102.6	106.0	102.0	104.0	102.4	103.4
5 p.m.		102.5		104.4	102.0	103.8	102.2	103.0
6 p.m.	102.0	102.5	102.2	103.5	101.6	103.5	102.2	103.0
7 p.m.	102.0	102.1	101.8	103.0	101.2	104.0	102.0	103.2
8 p.m.	101.6	101.6	101.8	102.4	101.5	104.0	102.2	102.4
9 p.m.	101.4	101.5	101.8	102.2	101.0	104.2	101.7	102.5
10 p.m.	101.8	101.2	101.8	102.0	101.2	103.8	102.0	102.5
11 p.m.	101.6		101.6		101.0	103.2	102.2	102.2
12 midnight	Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin K.	

Temperature as taken before and after the injection of tuberculin—Continued.

Hour.	315		316		317		318	
	Mar. 27. Before injection.	Mar. 28. After injection.	Mar. 27. Before injection.	Mar. 28. After injection.	Mar. 27. Before injection.	Mar. 28. After injection.	Apr. 12. Before injection.	Apr. 13. After injection.
7 a. m.		102.8		102.3		102.6		104.4
8 a. m.	100.0	102.8	102.0	103.0	101.6	102.0	100.6	103.0
9 a. m.	100.0	103.4	102.1	103.0	101.5	102.1	99.8	103.2
10 a. m.	100.5	103.6	102.8	103.9	101.4	102.4	100.0	104.6
11 a. m.	100.5	104.6	102.8	104.5	101.4	102.4	100.3	105.3
12 noon	100.8	105.0	102.4	106.0	101.0	102.5	100.5	106.0
1 p. m.	100.8	105.2	102.6	106.0	101.2	102.7	101.6	106.0
2 p. m.	101.0	104.6	102.6	105.4	101.3	101.8	101.6	105.6
3 p. m.	101.6	103.2	102.4	104.8	102.0	101.2	102.2	106.2
4 p. m.	102.2	103.4	103.1	105.4	102.2	102.4	103.2	106.8
5 p. m.	101.8	103.2	102.5	105.4	102.8	102.5	103.4	107.2
6 p. m.	102.2	103.0	101.4	105.0	102.4	102.2	102.8	106.5
7 p. m.	101.6	103.0	101.5	105.2	101.8	102.1	103.0	106.4
8 p. m.	101.8	102.0	101.6	104.6	102.0	102.2	102.8	106.0
9 p. m.	101.6	102.0	101.8	104.5	102.5	101.8	102.5	105.6
10 p. m.	101.5	101.8	101.6	104.5	101.8	102.0	102.5	105.8
11 p. m.	101.6	101.5	101.6	104.0	101.8	101.8	101.8	105.6
12 midnight	Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin S.	
Hour.	319		320		321		322	
	Mar. 27. Before injection.	Mar. 28. After injection.	Mar. 27. Before injection.	Mar. 28. After injection.	Mar. 27. Before injection.	Mar. 28. After injection.	Mar. 27. Before injection.	Mar. 28. After injection.
7 a. m.		103.0		102.2		101.8		102.0
8 a. m.	101.9	102.0	101.9	101.0	101.4	101.2	100.8	100.8
9 a. m.	101.8	102.0	101.6	101.4	101.6	101.2	101.4	100.8
10 a. m.	101.5	101.8	101.3	101.9	101.4	101.4	101.0	101.4
11 a. m.	101.4	101.8	101.4	102.2	101.3	101.4	100.9	102.4
12 noon	101.4	101.6	101.2	102.2	101.4	101.4	100.8	103.8
1 p. m.	101.4	101.8	101.0	102.6	101.2	101.4	101.2	104.2
2 p. m.	101.7	101.2	101.2	101.4	101.2	101.2	101.6	103.0
3 p. m.	101.9	100.8	102.4	101.0	101.8	100.4	101.8	101.0
4 p. m.	102.6	101.6	102.8	101.6	102.2	101.2	102.2	101.4
5 p. m.	102.8	102.8	102.8	102.0	102.0	102.0	102.8	102.8
6 p. m.	103.0	101.2	102.0	101.8	102.5	101.6	102.6	102.0
7 p. m.	102.6	102.2	102.2	101.8	102.4	101.8	102.6	102.2
8 p. m.	102.5	101.5	101.4	101.2	101.8	101.2	102.0	102.0
9 p. m.	101.4	101.6	102.2	101.4	102.0	101.2	102.0	101.2
10 p. m.	102.0	101.5	102.0	101.2	102.0	101.5	102.5	102.0
11 p. m.	102.0	101.3	101.6	101.0	101.5	101.2	102.0	101.5
12 midnight	Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin K.	
Hour.	323		324		325		326	
	Mar. 27. Before injection.	Mar. 28. After injection.	Mar. 27. Before injection.	Mar. 28. After injection.	May 25. Before injection.	May 26. After injection.	May 25. Before injection.	May 26. After injection.
7 a. m.		103.6		105.2		101.8		101.8
8 a. m.	101.0	102.8	100.9	105.0	101.2	101.8	102.0	102.0
9 a. m.	101.4	103.2	101.2	106.5		101.2		101.3
10 a. m.	101.4	103.8	101.0	107.0	101.4	101.1	101.9	101.5
11 a. m.	101.4	105.0	101.2	106.6		101.2		101.7
12 noon	101.4	105.0	102.0	106.2	101.2	101.3	101.6	101.8
1 p. m.	101.2	105.2	101.8	106.2		101.6		101.8
2 p. m.	101.6	103.6	101.9	106.0	101.1	101.4	101.7	102.4
3 p. m.	102.2	102.8	102.5	106.2		101.4		103.4
4 p. m.	102.6	102.5	102.4	106.0	101.7		101.8	
5 p. m.	103.4	102.8	102.8	106.0		103.0		103.0
6 p. m.	102.6	102.2	102.6	106.0	102.8	103.0	102.6	103.0
7 p. m.	102.2	102.6	102.2	106.2		102.6		102.5
8 p. m.	102.2	102.4	102.1	106.2	102.6	102.6	103.0	102.3
9 p. m.	102.5	102.0	102.6	105.0		102.2		102.0
10 p. m.	102.2	101.8	102.0	105.2	102.5		102.4	
11 p. m.	102.0	101.6	102.3	105.0				
12 midnight	Inj. tuberculin K.		Inj. tuberculin K.		Inj. tuberculin S.		Inj. tuberculin S.	

Temperature as taken before and after the injection of tuberculin—Continued.

Hour.	327		328		329		330	
	May 25. Before injection.	May 26. After injection.	Apr. 12. Before injection.	Apr. 13. After injection.	Apr. 12. Before injection.	Apr. 13. After injection.	Apr. 12. Before injection.	Apr. 13. After injection.
7 a. m.		102.4		101.8		104.0		103.0
8 a. m.	101.6	102.4	101.7	101.8	102.3	104.2	102.0	102.6
9 a. m.		102.2	101.5	102.8	102.3	104.9	101.4	103.9
10 a. m.	101.6	102.6	101.4	104.0	102.0	105.8	101.2	104.6
11 a. m.		102.9	101.4	104.0	102.2	105.6	101.0	105.2
12 noon	101.3	103.2	101.0	104.6	101.8	105.6	101.0	104.8
1 p. m.		103.0	100.8	104.6	101.6	105.4	101.2	104.0
2 p. m.	101.6	103.6	101.4	104.0	101.8	104.8	100.8	103.6
3 p. m.		103.0	101.4	103.4	102.8	105.2	100.7	103.2
4 p. m.	102.0		102.7	105.4	103.4	105.6	101.0	103.2
5 p. m.		103.2	102.0	105.4	103.2	105.2	101.5	103.5
6 p. m.	102.0	102.8	101.8	104.5	103.0	105.2	101.4	104.2
7 p. m.		102.5	101.5	104.2	102.7	105.0	101.4	103.6
8 p. m.	101.6	103.0	101.4	103.8	102.6	104.6	101.0	103.6
9 p. m.		102.6	101.2	103.0	102.7	104.2	101.0	103.4
10 p. m.	101.8		101.2	102.8	102.6	104.2	101.0	103.5
11 p. m.			101.0	102.5	102.2	104.0	101.0	103.2
12 midnight	Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.	
Hour.	331		332		333		334	
	Apr. 12. Before injection.	Apr. 13. After injection.	Apr. 12. Before injection.	Apr. 13. After injection.	Apr. 12. Before injection.	Apr. 13. After injection.	Apr. 12. Before injection.	Apr. 13. After injection.
7 a. m.		103.8		104.4		102.0		101.8
8 a. m.	101.8	103.2	101.2	104.2	102.4	102.0	101.4	101.6
9 a. m.	101.8	104.4	102.0	104.6	101.9	102.8	101.8	101.0
10 a. m.	101.4	105.2	101.8	105.8	101.0	103.5	100.4	101.0
11 a. m.	101.2	105.4	101.6	105.4	101.4	104.7	100.2	101.0
12 noon	101.0	104.8	101.4	105.4	101.5	105.4	101.2	101.0
1 p. m.	100.8	103.8	101.6	104.8	101.4	105.6	100.8	101.0
2 p. m.	101.2	103.2	101.6	104.2	101.0	103.9	100.6	101.2
3 p. m.	101.4	104.2	101.2	103.5	100.5	103.2	100.7	101.8
4 p. m.	101.8	105.2	102.8	104.9	101.8	103.5	101.8	102.2
5 p. m.	101.4	105.6	102.7	105.8	101.6	103.0	101.5	102.5
6 p. m.	101.6	105.8	102.4	106.2	101.6	102.2	101.6	102.2
7 p. m.	101.7	105.8	102.4	106.0	101.4	102.0	101.6	102.0
8 p. m.	101.6	105.6	102.2	105.4	101.5	101.8	101.4	102.0
9 p. m.	101.6	105.2	102.0	105.6	101.4	101.5	101.4	101.6
10 p. m.	101.8	105.2	102.0	105.2	101.4	101.5	101.2	101.8
11 p. m.	101.6	104.9	101.8	105.4	101.4	101.6	101.3	101.8
12 midnight	Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.	
Hour.	335		336		337		339	
	Apr. 12. Before injection.	Apr. 13. After injection.	Apr. 12. Before injection.	Apr. 13. After injection.	Apr. 12. Before injection.	Apr. 13. After injection.	May 1. Before injection.	May 2. After injection.
7 a. m.		102.2		102.0		102.8		101.3
8 a. m.	101.8	102.0	101.6	101.6	101.4	101.8		101.4
9 a. m.	101.6	102.6	102.0	101.6	101.4	102.2	101.6	101.2
10 a. m.	100.8	103.8	101.4	102.0	101.4	102.2	101.8	101.2
11 a. m.	100.9	104.8	101.2	102.4	101.2	103.4	101.4	101.2
12 noon	100.9	105.2	101.2	103.8	101.2	104.0		101.6
1 p. m.	101.2	104.2	101.0	104.4	101.2	104.8	101.1	101.4
2 p. m.	101.4	103.8	101.8	103.8	100.8	104.2	101.4	102.0
3 p. m.	101.5	102.8	101.6	103.5	101.8	104.4	101.2	102.0
4 p. m.	102.0	103.0	102.6	104.4	101.6	104.6	101.9	101.8
5 p. m.	101.8	102.6	102.8	104.9	101.6	104.8	103.0	102.5
6 p. m.	101.5	102.2	102.6	104.3	101.7	104.8	102.6	
7 p. m.	101.6	102.4	102.2	104.6	101.5	105.0	101.6	103.5
8 p. m.	101.6	101.8	102.0	103.6	102.0	101.6	101.6	103.0
9 p. m.	101.4	102.2	102.2	103.8	101.8	104.5	101.4	102.8
10 p. m.	101.4	101.8	101.7	103.4	101.8	104.5	101.0	102.2
11 p. m.	101.4	101.8	101.4	103.5	101.8	104.2	100.8	102.0
12 midnight	Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.	

Temperature as taken before and after the injection of tuberculin—Continued.

Hour.	340		341		342		343	
	May 1. Before injection.	May 2. After injection.	May 1. Before injection.	May 2. After injection.	May 1. Before injection.	May 2. After injection.	May 1. Before injection.	May 2. After injection.
7 a.m.		101.6		103.0		101.8		104.4
8 a.m.		102.0		104.0		102.2		105.0
9 a.m.	101.4	101.6	101.0	104.0	102.6	102.0	100.7	104.8
10 a.m.	101.0	102.2	100.8	104.8	102.2	101.6	101.0	105.0
11 a.m.	100.8	102.2	101.2	105.5	101.8	101.6	101.0	105.6
12 noon		102.0		106.0		101.7		106.2
1 p.m.	101.0	102.0	101.0	105.8	101.4	102.0	101.1	105.6
2 p.m.	101.2	102.4	101.5	105.6	101.4	102.4	101.0	105.8
3 p.m.	101.4	102.6	101.5	105.0	101.4	102.4	101.2	104.8
4 p.m.	102.2	102.0	102.3	105.0	102.8	101.4	101.6	104.0
5 p.m.	101.8	102.4	103.2	104.8	103.4	102.3	102.4	104.0
6 p.m.	101.6		103.4		103.2		102.6	
7 p.m.	101.0	102.4	102.2	106.0	102.0	104.2	101.6	103.8
8 p.m.	101.2	102.2	102.0	105.8	102.2	103.7	101.4	103.2
9 p.m.	100.8	101.8	101.7	105.5	101.9	103.5	101.2	102.8
10 p.m.	100.8	101.8	101.4	105.0	101.8	103.8	100.8	102.4
11 p.m.	100.8	101.7	101.4	104.8	101.8	103.4	100.8	102.2
12 midnight	Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.	
Hour.	344		345		346		347	
	May 1. Before injection.	May 2. After injection.	May 1. Before injection.	May 2. After injection.	May 1. Before injection.	May 2. After injection.	May 1. Before injection.	May 2. After injection.
7 a.m.		101.4		103.8		101.4		102.0
8 a.m.		101.4		104.2		101.2		101.8
9 a.m.	101.0	100.4	100.8	103.8	101.4	101.2	101.8	100.6
10 a.m.	100.8	100.4	101.2	103.8	100.2	101.8	101.4	100.8
11 a.m.	100.6	101.2	101.2	103.8	100.8	101.8	101.6	101.2
12 noon		100.2		105.4		102.8		101.2
1 p.m.	100.8	100.4	101.2	105.6	100.8	103.0	101.0	101.4
2 p.m.	101.3	101.2	101.2	106.0	101.0	103.2	101.6	101.6
3 p.m.	101.2	100.8	101.5	105.4	101.0	103.0	101.8	102.0
4 p.m.	102.1	101.6	101.4	104.8	101.8	103.2	102.4	103.0
5 p.m.	102.0	102.0	102.2	105.2	102.4	103.4	103.6	103.5
6 p.m.	102.4		102.4		102.6		102.8	
7 p.m.	101.2	102.0	101.2	106.4	101.5	103.5	103.0	104.2
8 p.m.	101.2	102.0	101.4	106.2	101.6	103.2	102.8	104.2
9 p.m.	101.2	101.5	101.2	105.8	101.4	102.8	102.8	103.4
10 p.m.	100.8	102.0	101.0	105.4	101.4	102.5	102.8	103.5
11 p.m.	100.8	101.8	100.8	105.0	101.0	102.2	102.8	103.2
12 midnight	Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.	
Hour.	348		349		350		351	
	May 1. Before injection.	May 2. After injection.	May 1. Before injection.	May 2. After injection.	May 1. Before injection.	May 2. After injection.	May 1. Before injection.	May 2. After injection.
7 a.m.		101.6		102.6		101.2		103.8
8 a.m.		101.6		103.2		101.8		103.8
9 a.m.	101.6	100.8	101.5	102.5	99.2	102.2	99.3	104.0
10 a.m.	101.2	101.4	101.6	102.8	99.1	102.1	100.0	103.6
11 a.m.	100.8	101.8	101.5	105.0	99.5	102.2	100.0	103.8
12 noon		102.4		103.4		103.0		104.8
1 p.m.	101.0	102.4	101.5	103.4	100.6	102.8	101.0	104.8
2 p.m.	101.4	102.6	101.6	103.3	100.8	103.4	101.2	105.0
3 p.m.	101.2	102.2	101.6	103.0	101.3	103.5	101.6	104.6
4 p.m.	101.8	102.8	102.0	102.8	101.8	104.2	102.2	104.6
5 p.m.	102.0	103.2	102.0	103.2	102.2	105.0	102.2	104.7
6 p.m.	101.6		101.8		101.6		102.4	
7 p.m.	102.0	103.2	101.6	103.8	101.6	104.8	102.2	105.6
8 p.m.	102.2	102.8	101.8	103.2	101.2	104.6	102.2	105.2
9 p.m.	102.2	102.6	101.4	102.7	100.8	104.4	102.0	104.5
10 p.m.	102.2	102.4	101.4	102.2	100.8	103.8	101.8	104.3
11 p.m.	102.2	102.2	102.0	102.0	100.8	103.5	101.2	104.0
12 midnight	Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.	

Temperature as taken before and after the injection of tuberculin—Continued.

Hour.	352		353		354		355	
	May 1. Before injection.	May 2. After injection.	May 1. Before injection.	May 2. After injection.	May 25. Before injection.	May 26. After injection.	May 25. Before injection.	May 26. After injection.
7 a. m.		104.3		102.6		102.4		102.8
8 a. m.		103.8		102.8	101.5	102.5	101.8	102.6
9 a. m.	102.6	102.2	101.7	101.0		102.0		101.8
10 a. m.	102.0	102.2	101.3	101.8	101.6	101.6	101.9	101.7
11 a. m.	102.0	102.6	101.4	102.3		102.4		101.8
12 noon		102.4		103.0	100.7	102.4	101.6	101.8
1 p. m.	102.2	103.0	101.0	102.6		102.0		101.9
2 p. m.	102.6	103.0	101.6	102.8	101.0	102.4	101.5	101.8
3 p. m.	102.4	102.6	101.4	102.6		101.8		101.8
4 p. m.	103.7	102.6	102.4	103.2	101.5		101.7	
5 p. m.	104.0	104.0	102.6	103.5		102.9		102.6
6 p. m.	103.4		101.6		102.6	103.0	102.8	102.8
7 p. m.	103.4	104.2	101.6	104.3		103.0		102.0
8 p. m.	103.5	104.0	101.4	104.2	102.6	102.8	103.2	102.6
9 p. m.	103.0	103.7	101.4	104.0		103.0		102.6
10 p. m.	102.8	103.4	101.4	103.6	102.0		102.5	
11 p. m.	102.6	103.2	101.4	103.2				
12 midnight	Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.	
Hour.	356		357		358		359	
	May 25. Before injection.	May 26. After injection.	May 25. Before injection.	May 26. After injection.	May 25. Before injection.	May 26. After injection.	May 25. Before injection.	May 26. After injection.
7 a. m.		101.5		102.5		102.2		101.4
8 a. m.	101.6	101.4	101.4	102.2	101.2	102.0	102.0	101.4
9 a. m.		100.8		101.8		102.2		101.2
10 a. m.	101.1	101.2	101.5	101.7	100.6	101.8	102.0	100.8
11 a. m.		101.2		101.5		101.8		100.6
12 noon	101.1	101.4	101.2	101.5	101.1	101.8	102.1	100.8
1 p. m.		101.4		101.3		101.8		101.2
2 p. m.	101.3	101.7	101.4	101.4	101.4	102.0	102.8	101.5
3 p. m.		101.9		101.4		102.0		101.2
4 p. m.	101.2		101.6		101.6		102.6	
5 p. m.		102.5		102.0		102.9		102.2
6 p. m.	102.0	102.8	103.0	102.0	101.8	102.0	103.4	103.0
7 p. m.		102.7		102.0		102.2		102.8
8 p. m.	102.0	102.4	103.1	101.8	101.6	102.1	103.2	Calved.
9 p. m.		102.2		101.5		102.2		
10 p. m.	101.7		105.0		101.3		103.0	
11 p. m.								
12 midnight	Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.	
Hour.	360		361		362		363	
	May 25. Before injection.	May 26. After injection.	May 25. Before injection.	May 26. After injection.	May 25. Before injection.	May 26. After injection.	May 25. Before injection.	May 26. After injection.
7 a. m.		101.8		102.5		102.2		101.8
8 a. m.	102.2	101.8	102.2	102.4	101.0	102.4	100.9	102.0
9 a. m.		101.5		101.7		102.2		101.6
10 a. m.	100.8	101.4	102.0	101.7	100.8	102.0	100.8	101.6
11 a. m.		101.4		101.5		101.7		101.6
12 noon	101.0	101.6	100.9	101.6	100.7	102.0	100.7	101.5
1 p. m.		101.3		101.3		101.9		101.6
2 p. m.	101.5	101.8	101.4	101.8	100.9	102.2	101.0	102.0
3 p. m.		101.6		101.8		102.3		102.2
4 p. m.	101.2		101.3		101.6		101.4	
5 p. m.		102.0		102.2		102.5		102.7
6 p. m.	102.2	102.5	101.8	102.0	102.0	103.0	102.4	102.7
7 p. m.		102.2		102.4		102.6		102.3
8 p. m.	102.1	101.8	102.4	102.1	102.4	102.6	102.8	102.2
9 p. m.		101.8		102.0		102.4		102.2
10 p. m.	101.9		102.0		102.3		102.2	
11 p. m.								
12 midnight	Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.	

Temperature as taken before and after the injection of tuberculin—Continued.

Hour.	305		308		309		315	
	May 25. Before injection.	May 26. After injection.	May 25. Before injection.	May 26. After injection.	May 25. Before injection.	May 26. After injection.	May 25. Before injection.	May 26. After injection.
7 a. m.		101.7		101.2		101.4		104.0
8 a. m.	100.8	101.7	101.8	101.6	102.0	101.5	101.8	101.6
9 a. m.		101.5		101.4		101.6		104.4
10 a. m.	100.6	101.1	101.4	101.4	101.2	101.2	101.4	105.2
11 a. m.		101.3		101.4		101.0		105.2
12 noon	100.6	101.4	101.3	101.4	101.3	100.8	101.2	105.3
1 p. m.		101.3		101.4		101.0		104.7
2 p. m.	100.9	101.8	101.3	101.6	101.3	101.2	101.4	104.6
3 p. m.		101.8		101.0		101.2		104.3
4 p. m.	101.2		101.9		101.8		102.0	
5 p. m.		103.6		102.7		102.5		104.6
6 p. m.	101.6	103.0	102.4	103.0	101.5	102.6	102.8	104.5
7 p. m.		102.0		103.0		102.4		104.2
8 p. m.	101.4	102.0	102.2	102.7	101.6	102.2	103.1	104.0
9 p. m.		101.8		102.6		101.8		104.0
10 p. m.	101.0		101.9		101.2		103.0	
11 p. m.								
12 midnight.	Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.	

Hour.	319		320		321		322	
	May 25. Before injection.	May 26. After injection.	May 25. Before injection.	May 26. After injection.	May 25. Before injection.	May 26. After injection.	May 25. Before injection.	May 26. After injection.
7 a. m.		102.4		101.6		101.6		101.4
8 a. m.	102.7	102.5	101.7	101.5	101.2	101.6	101.5	101.5
9 a. m.		101.4		101.2		101.5		100.0
10 a. m.	102.0	101.5	101.5	101.4	101.6	101.4	101.3	100.5
11 a. m.		101.6		101.2		102.0		101.3
12 noon	101.4	101.8	101.2	101.5	101.6	101.9	100.9	101.6
1 p. m.		102.0		101.6		101.8		102.0
2 p. m.	101.6	102.2	101.4	101.6	101.5	102.0	101.2	101.9
3 p. m.		101.8		101.6		101.9		101.8
4 p. m.	103.0		101.4		101.9		101.4	
5 p. m.		102.6		103.4		102.6		102.8
6 p. m.	103.6	102.9	102.0	103.0	102.0	102.7	102.2	102.4
7 p. m.		102.8		102.6		102.6		102.6
8 p. m.	103.5	102.7	101.8	102.6	101.5	102.5	102.0	102.5
9 p. m.		102.6		102.5		102.2		102.2
10 p. m.	103.0		101.8		101.2		101.6	
11 p. m.								
12 midnight.	Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.	

Hour.	334		336		339	
	May 25. Before injection.	May 26. After injection.	May 25. Before injection.	May 26. After injection.	May 25. Before injection.	May 26. After injection.
7 a. m.		101.8		102.6		102.0
8 a. m.		100.0		101.8		102.0
9 a. m.		101.0		102.6		101.4
10 a. m.		100.9		101.0		101.4
11 a. m.		101.2		102.0		101.3
12 noon		101.4		102.8		101.2
1 p. m.		100.3		101.2		101.0
2 p. m.		101.8		103.2		101.8
3 p. m.		101.6		103.0		101.8
4 p. m.		101.2		103.6		101.8
5 p. m.		102.1		103.6		102.4
6 p. m.		101.6		102.0		102.0
7 p. m.		102.7		103.6		102.6
8 p. m.		102.2		103.6		102.6
9 p. m.		102.4		103.6		103.5
10 p. m.		101.5		103.8		102.5
11 p. m.		101.8		103.6		102.2
12 midnight.	Inj. tuberculin S.		Inj. tuberculin S.		Inj. tuberculin S.	

FURTHER EXPERIMENTAL OBSERVATIONS ON THE PRESENCE OF TUBERCLE BACILLI IN THE MILK OF COWS.

By E. C. SCHROEDER, M. D. V.

The following experiments to demonstrate the presence of tubercle bacilli in milk are a continuation of the observations published on page 60 of Bulletin No. 3, 1893, of the Bureau of Animal Industry.

In the former work the principal question to be solved was the relation which exists between the condition of a tuberculous animal and the degree of milk infection. The same question was kept in view in the present work, but in addition to it some information was sought concerning the probable extent to which tubercle bacilli occur in the general city milk supply. Hence the following experiments divide themselves into two series: The first deals with city milk in the condition in which it reaches the consumer, and the second, with milk from cows without visible disease of the udder in which tuberculosis was diagnosed, either through a physical examination, or through the use of tuberculin injections.

The milk was injected into the abdominal cavity of guinea pigs partly in the form in which it was obtained from the dealer or the cow and partly after it had undergone a centrifugal process. The latter consisted in pouring a quantity of milk into glass tubes and rotating it in them fifteen minutes by means of a small hand centrifugal machine, which was made to revolve 1,500 times per minute. The fluid in the bottom of the tubes, together with the sediment, if there was any, was retained for injection and the balance of the milk discarded. The object of the centrifugal process was to concentrate, in the smallest amount of fluid, any tubercle bacilli present. It has been shown experimentally that the conduct of different bacteria varies in fluids subjected to centrifugal motion. Some bacteria rise to the surface, while others, and among them the tubercle bacilli, gravitate to the bottom.*

Cover-glass preparations were stained and examined for tubercle bacilli from every specimen of milk, excepting that from cow No. 283, but were found in no instance. Multinuclear leucocytes in greater or smaller numbers were present in the cover glasses from all specimens of milk excepting those marked dairy H and L. Among the numerous

* Scheurlen, Arbeiten a. d. Kaiserl. Gesundheitsamte, VII (1891), p. 269.

bacteria present a large coccus and a large thick bacillus predominated. Occasionally streptococci were seen in small numbers.

Nothing was known of the condition of the milk from the dairies and dealers at the time it was procured for examination, and consequently some precautions were believed necessary to avoid diseases of the guinea pigs from the accidental presence of miscellaneous septic or toxic bacteria. For this reason the milk injected into the first six guinea-pigs, which are given separately in Table I, was previously exposed to an elevated temperature, 60° C., for fifteen minutes. This procedure, it was thought would destroy the other germs, if such were present, or reduce their virulence sufficiently to make them harmless, without seriously affecting the tubercle bacilli. As a control in the heating process a suspension of tubercle bacilli was made in the manner described below and injected into the abdominal cavity of a guinea pig.

A small amount of the surface growth on an glycerin-agar culture of tubercle bacilli was scraped off and thoroughly triturated with 10 cc. of beef infusion. When the beef infusion had assumed a homogeneous cloudiness, and no clumps or solid particles visible to the naked eye remained, 0.5 cc. was removed with a sterile pipette and added to 5 cc. of milk, which was then exposed to a temperature of 60° C. for fifteen minutes.

The guinea pig which received this injection was chloroformed after eighty-five days and on post-mortem examination no lesions were found. Even before the guinea pig was killed the inference from its uninterrupted good condition was that the few tubercle bacilli which might be present in a specimen of mixed milk could not undergo the heating process without sacrificing their vitality. This view was further supported by the death of two guinea pigs in twenty-five and twenty-eight days, respectively, which were injected, shortly after the first guinea pig was injected, with similar suspensions of tubercle bacillus which had not been previously exposed to an elevated temperature. Hence after the first six injections, which are given in the following table, the heating process was discontinued:*

TABLE I.

No. of guinea pig.	Date of injection.	Date when killed.	Quantity injected.	Centrifugalized from—	Weight of guinea pig when injection made.	Weight when killed.	Source of milk.	Autopsy.
			cc.	cc.	Ounces.	Ounces.		
444 ♀	June 28, 1893	Sept. 23, 1893	5	40	20½	22	Dairy 1 ..	Negative.
445 ♀	...do	...do	5	40	24	31	...do	Do.
447 ♀	June 30, 1893	...do	5	40	14	18	Dairy 2 ..	Do.
448 ♀	...do	...do	5	40	18	22	...do	Do.
455 ♂	July 8, 1893	Oct. 17, 1893	5	40	19	20½	Dairy 3 ..	Do.
456 ♂	...do	...do	5	40	17	20	...do	Do.

* The 40 cc. here represent the lower strata in a bottle containing 100 cc., which had stood on ice twenty-four hours.

* This rapid destruction of tubercle bacilli from a culture on glycerin agar (fifteen minutes at 60° C.) does not harmonize with the results of others. De Man (Archiv. f. Hygiene, XVIII., p. 123) finds that at 60° C., one hour is necessary to destroy tubercle bacilli in milk.—T. S.

The next table gives the results of 40 injections, which represent 19 specimens of milk. The milk, excepting that marked dairy Q, was delivered to private residences or bought in different sections of Washington, D. C., and nothing is known about the cows by which it was produced. Dairy milk Q was obtained from a herd of cattle in Virginia, numbering twelve milch cows, eight of which gave high temperature reactions after injection with tuberculin. In two of the eight cows tuberculosis could be readily diagnosed on physical examination. The milk from the twelve cows was drawn in the usual manner at the evening milking, poured into a large can, and allowed to stand about one-half hour. The can was then thoroughly agitated three to five minutes and a specimen of milk dipped out of the top and taken in a sterile bottle to the laboratory, where it was used for injections the following morning.

The use of the names "dairy" and "dealer" in specifying the source of the different samples of milk represented in the table is to distinguish a dairy or regularly established milk business from dealers with whom the sale of milk forms only a small fraction of their trade.

The following table records the injection of mixed milk obtained from the general milk supply of Washington, D. C. The injections were made into the peritoneal cavity, and the amount injected in each case was 5 cc:

TABLE II.

Number and sex of guinea pigs.	Date of injection.	Date when killed.	Centrifugalized from—	Weight of guinea pig when injection made.	Weight when killed.	Source of milk.	Volume of cream per 100 of milk.	Microscopic examination of sediment in centrifuge tubes.	Absence or presence of tuberculosis: present +, absent —.
457 ♀	July 12, 1893	Oct. 17, 1893	cc. 40	Ounces. 16	18	Dairy A	10	Slight sediment; a few leucocytes.	—
458 ♀	do	do	do	17	18	Dairy B	10	Very slight sediment; numerous bacteria.	—
459 ♀	July 14, 1893	do	40	12	21	Dairy C	6	Numerous leucocytes and bacteria.	—
460 ♀	do	do	do	19	20	do	12	do	—
461 ♀	July 15, 1893	do	40	15	20	do	24	do	—
462 ♀	do	Died July 17, 1893.	do	do	do	do	7½	Few leucocytes and bacteria.	—
463 ♀	July 19, 1893	Oct. 31, 1893	40	20	24	Dairy D	6	do	—
464 ♀	do	do	do	14	24	Dairy E	10½	do	—
465 ♀	July 20, 1893	do	40	18	24	do	6	do	—
466 ♀	do	do	do	12	16½	do	10½	No sediment in centrifuge tubes.	—
467 ♀	July 28, 1893	Died Aug. 15, 1893.	40	do	do	do	6½	Very abundant sediment; very many leucocytes.	—
468 ♀	do	Oct. 31, 1893	40	20	23½	Dairy G	5½	Leucocytes and a few bacteria.	—
469 ♀	Aug. 2, 1893	do	40	16	20	Dairy H	9	Numerous leucocytes.	—
470 ♀	do	do	do	19	22	Dairy I	10	Numerous bacteria.	—
73 ♀	Jan. 31, 1894	Apr. 14, 1894	40	16	18	Dairy J	6½	Considerable number of bacteria and leucocytes.	—
74 ♀	do	do	do	18	21½	Dairy K	3½	Bacteria, leucocytes, and dirt.	—
75 ♀	do	Died Apr. 6, 1894.	40	18	14	Dairy L	4½	Leucocytes and bacteria.	—
76 ♀	do	Apr. 7, 1894	do	17	17½	Dairy M	4	Leucocytes, bacteria, and dirt.	—
77 ♀	do	Apr. 14, 1894	40	18	13	Dairy N	10	Few leucocytes; considerable number of bacteria.	—
78 ♀	do	do	do	19	20	do	4	do	—
83 ♀	Feb. 2, 1894	May 2, 1894	40	14	20	Dairy O	4½	Leucocytes, bacteria, and dirt.	—
84 ♀	do	do	do	17	23	Dairy P	10	Leucocytes and bacteria.	—
85 ♀	do	do	40	13½	20	Dairy Q	4	Leucocytes, bacteria, and dirt.	—
86 ♀	do	do	do	20	30	do	10	Leucocytes, bacteria, and dirt.	—
87 ♀	do	do	40	14	18	do	4½	Leucocytes, bacteria, and dirt.	—
88 ♀	do	do	do	16	21	do	4½	Leucocytes, bacteria, and dirt.	—
89 ♀	Feb. 3, 1894	May 1, 1894	40	13	19	do	4	Leucocytes, bacteria, and dirt.	—
90 ♀	do	do	do	15	20	do	10	Leucocytes, bacteria, and dirt.	—
91 ♀	do	do	40	12½	17	do	4	Leucocytes, bacteria, and dirt.	—
92 ♀	do	do	do	12	11	do	10	Leucocytes, bacteria, and dirt.	—
93 ♀	do	do	40	12	21	do	10	Leucocytes, bacteria, and dirt.	—
94 ♀	do	do	do	11½	18	do	10	Leucocytes, bacteria, and dirt.	—
103 ♀	Feb. 9, 1894	May 2, 1894	40	11½	15	do	10	Leucocytes, bacteria, and dirt.	—
104 ♀	do	do	do	15	22	do	10	Leucocytes, bacteria, and dirt.	—

176 ♀	.....	Apr. 9, 1894	July 13, 1894	40	84	13	16	{ A large amount of amorphous matter; a con- siderable number of leucocytes and bacteria of different kinds.
177 ♀	.....	do	do	40	114	19	16	{
178 ♀	.....	do	do	40	84	15	16	{
179 ♀	.....	do	do	40	84	20	14	{ Microscopic examination same as above.
180 ♀	.....	do	do	40	94	17 1/2	14	{
181 ♀	.....	do	Died Apr. 21, 1894.	40	94	17 1/2	14	{ General peritonitis.

* For post-mortem notes see next page.

Guinea pig No. 462 died of general peritonitis two days after the injection.

Guinea pig No. 467 died of general peritonitis eighteen days after the injection. An abscess about one-half inch in diameter had formed at the seat of injection on the inner surface of the abdominal wall; this had ruptured and discharged its contents into the abdominal cavity. Cover glasses from the fluid in the abdominal cavity showed the presence of cocci in considerable numbers.

Guinea pig No. 75 died of tuberculosis sixty-three days after the injection. There were tubercles on omentum, a large tuberculous spleen, and large yellow necrotic patches in liver. Glands behind stomach and spleen very large and necrotic. Sternal and bronchial glands quite large, firm, necrotic. Lungs flesh red; much serum in pleural cavities. Scattering subpleural tubercles on lungs.* Cover glasses from various regions showed an abundance of tubercle bacilli.

Guinea pig No. 93 was affected with a disease the nature of which was not recognized. The autopsy notes are as follows:

Liver, pale in color and sprinkled with small, irregular, grayish or yellowish-white foci. Spleen enlarged to five times its normal dimensions and containing foci similar to those in the liver. The kidneys appear as two large, white tumors; on section they are seen to be more or less completely degenerated.† No tubercle bacilli or other germs detected in cover-glass preparations.

We see thus that among the 19 specimens of milk obtained from the general city milk supply, one contained the bacillus of tuberculosis in sufficient numbers to produce the disease in one of the two guinea pigs injected with it. Why one guinea pig should have remained unaffected is an unsolved question. The guinea pig which died of tuberculosis was injected with the milk in the form in which it came from the dairy, while the guinea pig which escaped the infection was injected with a specimen of the same milk which had previously been subjected to the centrifugal process. In this connection it must be remembered that the amount of milk which can be injected into the abdominal cavity of a guinea pig with any degree of safety is very small.

We may summarize the results recorded in Table II by the statement that now and then the mixed milk of dairies may contain comparatively large numbers of tubercle bacilli. In the foregoing series one out of 19 samples from different dealers or dairies contained tubercle bacilli.

Table III gives the results obtained by the injection of milk from cows in which tuberculosis was diagnosed either with or without the aid of tuberculin.

The milk was collected in sterile bottles, and, with the exception of samples from cow No. 283, represents a mixture of the product from all

* A careful examination of the lesions in this animal showed that the infection started from the abdomen and was due to the milk injected. The guinea pigs used in this laboratory are bred on the experiment station. Spontaneous tuberculosis has never been found in any case.—T. S.

† The disease in this guinea pig might be mistaken for tuberculosis. It differs from the latter, however, in the restricted, irregular size of the minute foci and the disease of the kidneys, which are almost invariably normal in tuberculous guinea pigs. The microscopic examination of the kidneys showed an extensive interstitial nephritis. The foci in the liver are situated in the interlobular tissue, and consist of infiltrations of round cells.—T. S.

four quarters of the udder. The milk from each quarter of the udder of cow No. 283 was drawn into a separate sterile bottle. Guinea pig No. 33 was injected with the milk from the right forward quarter, No. 34 from the left forward quarter, No. 35 from the right hind quarter, and No. 36 from the left hind quarter.

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TABLE III.

Table recording the injection of milk from cows which were either known to be tuberculous or which gave a positive tuberculin reaction. Injections of 5 cc. in each case were made into the peritoneal cavity.

Number and sex of guinea pig.	Date of injection.	Date when killed.	Centrifugalized from—	Weight of guinea pig when injection made.	Weight when killed.	Source of milk.	Volume of cream per 100 of milk.	Microscopic examination of sediment in centrifuge tubes.	Absence or presence of tubercles (present +, absent —).
9♂	Nov. 25, 1893	Feb. 27, 1894	cc.	Guinea.	Guinea.	Cow No. 272		No bacteria, a small number of leucocytes.	—
10♂	do	do	40	25	24	Cow No. 272		do	—
11♂	do	do	40	25	21	Cow No. 273		do	—
12♂	do	do	40	25	25	Cow No. 273		do	—
13♂	do	do	40	18	21	Cow No. 274		do	—
14♂	do	do	40	23	20	Cow No. 274		do	—
15♀	do	do	40	17	22	Cow No. 275		do	—
16♀	do	do	40	22	23	Cow No. 275		do	—
17♀	do	do	40	17	24	Cow No. 276		do	—
18♀	do	do	40	20	21	Cow No. 276		do	—
19♀	do	do	40	19	20	Cow No. 279		do	—
20♀	do	do	40	16	24	Cow No. 279		do	—
33♂	Dec. 19, 1893	Mar. 16, 1894		22	24	Cow No. 283		No cover glasses from milk examined.	—
34♂	do	do		16	19	Cow No. 283		do	—
35♂	do	do		25	24	Cow No. 283		do	—
36♂	do	do		21	24	Cow No. 283		do	—
60♂	Jan. 21, 1894	Apr. 14, 1894		14	17	Cow No. 268		No bacteria, only a few leucocytes.	+
61♂	do	do	40	16	20	Cow No. 268		do	—
62♂	do	do	40	15	16	Cow No. 273		do	—
63♀	do	do	40	14	17	Cow No. 273		do	—
64♀	do	do	40	15	18	Cow No. 276		do	—
65♀	do	do	40	15	17	Cow No. 276		do	—
66♀	do	do	40	14	18	Cow No. 279		do	—
67♀	do	do	40	12	16	Cow No. 279		do	—
95♀	Feb. 9, 1894	May 3, 1894		12	17	Cow No. W. 1	64	Large number of leucocytes	—
96♀	do	do	40	13	22	Cow No. W. 1	74	Few leucocytes	—
97♀	do	do	40	14	19	Cow No. W. 2	20	do	—
98♀	do	do	40	13	20	Cow No. W. 2	41	Large numbers of leucocytes	—
99♀	do	do	40	10	18	Cow No. W. 3		do	—
100♀	do	do	40	12	15	Cow No. W. 3		do	—
101♀	do	do	40	12	18	Cow No. W. 8		do	—
102♀	do	do	40	10	16	Cow No. W. 8		do	—

* For special note see next page.

Guinea pig No. 35 was found tuberculous when killed. The dorsal third of the spleen was infiltrated with tubercles, probably by contiguity from the lymph glands associated with it, which are much enlarged and necrotic. The left testicle is converted into a thin walled sac filled with a thick, yellowish pus, resembling flour paste in consistency. Tubercle bacilli present in cover glasses. A guinea pig inoculated with a particle of spleen pulp became tuberculous.

On post-mortem examination cow No. 283 was found to be extensively tuberculous, but the udder and pubic lymph glands were found free from tubercular lesions after a very careful naked-eye examination.

The second series of inoculations thus include the milk from 12 tuberculous cows, from three of which injections were made at two different times sixty days apart. The milk from only one cow, an animal practically in the last stages of more or less generalized tuberculosis, produced the affection in one of the four guinea pigs injected with it.

In addition to these experiments, a third series was tried by injecting repeatedly into a number of guinea pigs the milk of the same animal. It was assumed that by increasing in this way the quantity of milk injected into the same guinea pig from the same cow more positive results might be obtained. The milk was injected directly into the abdominal cavity in every case. When centrifugalized, the quantity injected was derived from 40 cc. (1½ ounces).

MILK FROM COW No. 286.

This cow is in the last stages of tuberculosis, but has no visible affection of the udder.* See No. 286, Table v, p. 144.

Guinea pig No. 146 ♀.

March 16. Weight of guinea pig, 13 ounces; injected 5 cc. centrifuge milk.

March 19. Weight of guinea pig, 13½ ounces; injected 5 cc. centrifuge milk.

March 24. Weight of guinea pig, 14 ounces; injected 5 cc. untreated milk.

April 4. Weight of guinea pig, 14½ ounces; injected 5 cc. untreated milk.

April 12. Weight of guinea pig, 11½ ounces; no injection.

Up to the time of the last injection, on April 4, the guinea pig remained in good condition, and had been gradually gaining in weight. On April 18 it was found in a dying condition, and was killed and examined. Extremely emaciated. At the seat of one injection a small abscess, containing pale yellow pus. Similar abscesses, not less than a dozen, varying in size from a mustard seed to a pea, in the abdominal cavity. Adhesion of the liver to the abdominal wall and the stomach. Cover glasses show the presence of a coccus in considerable number.†

* For the extent of the disease and its distribution in this animal, see No. 283, Table v, p. 144. — T. S.

† The lesions in this and other guinea pigs which were inoculated with milk from cow No. 286 were evidently due to *Staphylococci* in the udder. The lesions included peritonitis, suppurative pericarditis, and multiple abscesses in the internal organs of those guinea-pigs which died prematurely, and firm adhesions of liver, stomach, and intestines to neighboring structures in those that recovered. *Staphylococci* were isolated from the milk directly and from one of the guinea pigs. This subject will receive more attention.—T. S.

Guinea pig No. 147 ♀.

March 16. Weight of guinea pig, 11 ounces; injected 5 cc. centrifuge milk.

March 19. Weight of guinea pig, 11 ounces; injected 5 cc. centrifuge milk.

March 24. Weight of guinea pig, 11 ounces; injected 5 cc. centrifuge milk.

March 26. Dead.

Marked injection of the veins of subcutis over the abdomen. Whitish discoloration of abdominal muscles at the seat of injection. Extensive viscid exudate in the abdomen. Pseudo-membranous deposit on spleen and liver, with whitish clumps intermixed. Hyperæmia of lungs with viscid, translucent pleural exudate.

No bacteria in cover glasses from abdominal exudate.

Guinea pig No. 154 ♀.

March 21. Weight of guinea pig, 11½ ounces; injected 5 cc. centrifuge milk.

March 24. Weight of guinea pig, 11 ounces; injected 5 cc. untreated milk.

April 4. Weight of guinea pig, 11 ounces; injected 5 cc. untreated milk.

April 12. Weight of guinea pig, 9½ ounces; no injection.

April 23. Weight of guinea pig, 10½ ounces; no injection.

July 13. Weight of guinea pig, 19 ounces.

Chloroformed and examined post-mortem. Firm adhesion of liver to diaphragm and stomach.

Guinea pig No. 155 ♀.

March 21. Weight of guinea pig, 14½ ounces; injected 5 cc. centrifuge milk.

March 24. Weight of guinea pig, 13½ ounces; injected 5 cc. untreated milk.

April 4. Weight of guinea pig, 15 ounces; injected 5 cc. untreated milk.

April 12. Weight of guinea pig, 15 ounces; injected 5 cc. untreated milk.

May 1. Died this morning.

The abdominal cavity is filled with a turbid reddish fluid. In the liver is a large abscess which is filled with a dirty yellowish red fluid. What is left of the liver tissue is soft and mushy in character, dark red in color, and sprinkled with minute necrotic areas. The intestine is adherent to the abdominal wall and the stomach to the abdominal wall and liver. The entire thoracic cavity is filled with a turbid reddish fluid, which coagulates slowly and forms a soft gelatinous clot. Lungs in a state of extreme congestion and very œdematous. Heart with the pericardium adherent. Between the heart and the pericardium, one small abscess. One small abscess between the skin and the abdominal wall.

The condition of the cow had been growing rapidly worse and had reached a stage at the time these injections were undertaken which would have led the average dairyman to exclude her from his herd.

Guinea pig No. 187 ♂.

May 5. Weight of guinea pig, 18½ ounces; injected 5 cc. untreated milk.

May 19. Weight of guinea pig 17½ ounces; injected 5 cc. untreated milk.

May 24. Weight of guinea pig, 17½ ounces; injected 5 cc. untreated milk.

July 13. Weight of guinea pig, 16½ ounces.

Chloroformed and examined post-mortem. Adhesion of liver to stomach, and intestine to abdominal wall.

Guinea pig No. 188 ♂.

May 14. Weight of guinea pig, 24½ ounces; injected 5 cc. untreated milk.

May 19. Weight of guinea pig, 25½ ounces; injected 5 cc. untreated milk.

May 24. Weight of guinea pig, 25½ ounces; injected 5 cc. untreated milk.

July 13. Weight of guinea pig, 28 ounces.

Chloroformed and examined post-mortem. No lesions.

Guinea pig No. 189 ♂.

May 19. Weight of guinea pig, 12½ ounces; injected 5 cc. untreated milk.

May 24. Weight of guinea pig, 12½ ounces; no injection.

July 13. Weight of guinea pig, 19 ounces.

Chloroformed and examined post-mortem. No lesions.

MILK FROM COW NO. 285.

This cow gave a marked tuberculin reaction, but is in fairly good condition and has no visible affection of the udder.

Guinea pig No. 148 ♀.

March 16. Weight of guinea pig, 13½ ounces; injected 5 cc. centrifuge milk.

March 19. Weight of guinea pig, 14 ounces; injected 5 cc. centrifuge milk.

March 24. Weight of guinea pig, 14 ounces; injected 5 cc. untreated milk.

April 4. Weight of guinea pig, 14½ ounces; injected 5 cc. untreated milk.

April 12. Weight of guinea pig, 14 ounces; injected 5 cc. untreated milk.

April 16. Weight of guinea pig, 15 ounces; no injection.

July 13. Weight of guinea pig, 23 ounces.

Chloroformed and examined. Adhesion of the intestine in two places to the abdominal wall.

Guinea pig No. 149 ♀.

March 16. Weight of guinea pig, 13½ ounces; injected 5 cc. centrifuge milk.

March 19. Weight of guinea pig, 13 ounces; injected 5 cc. centrifuge milk.

March 24. Weight of guinea pig, 13¾ ounces; injected 5 cc. untreated milk.

April 4. Weight of guinea pig, 14 ounces; injected 5 cc. untreated milk.

April 12. Weight of guinea pig, 13½ ounces; injected 5 cc. untreated milk.

April 23. Weight of guinea pig, 14½ ounces; no injection.

July 13. Weight of guinea pig, 22 ounces.

Chloroformed and examined post-mortem. Adhesion of stomach and intestine to liver.

Guinea pig No. 156 ♀.

March 21. Weight of guinea pig, 14½ ounces; injected 5 cc. centrifuge milk.

March 24. Weight of guinea pig, 14½ ounces; injected 5 cc. untreated milk.

April 4. Weight of guinea pig, 15 ounces; injected 5 cc. untreated milk.

April 12. Weight of guinea pig, 15½ ounces; injected 5 cc. untreated milk.

April 13. Found dead.

On post-mortem examination a number of whitish clumps (probably casein) were found in the abdominal cavity between the coils of intestine and sprinkled over the liver, spleen, etc. A considerable amount of pale red, partly translucent, fluid in the abdominal cavity. General discoloration of the abdominal wall and serous surface of the intestine.

Guinea pig No. 157 ♀.

March 21. Weight of guinea pig, 10½ ounces; injected 5 cc. centrifuge milk.

March 24. Weight of guinea pig, 9¾ ounces; injected 5 cc. untreated milk.

April 4. Weight of guinea pig, 10 ounces; injected 5 cc. untreated milk.

April 12. Weight of guinea pig, 9½ ounces; injected 5 cc. untreated milk.

April 18. Found dead this morning.

Autopsy revealed the same condition as in guinea pig No. 146. There was, in addition, a collapsed and edematous condition of the lungs and a purulent pericarditis.

MILK FROM COW NO. 290.

This cow is supposed to be in an advanced stage of tuberculosis. She has given a reaction upon injection with tuberculin several times, but has no visible udder affection.

Guinea pig No. 183 ♂.

April 18. Weight of guinea pig, 13 ounces; injected 5 cc. untreated milk.

April 23. Weight of guinea pig 14½ ounces; injected 5 cc. untreated milk.

April 28. Weight of guinea pig, 15 ounces; injected 5 cc. untreated milk.

May 5. Weight of guinea pig, 16 ounces; injected 5 cc. untreated milk.

July 13. Weight of guinea pig, 23 ounces.

Chloroformed and examined post-mortem. Slight adhesion of intestine to abdominal wall.

Guinea pig No. 184 ♂.

April 18. Weight of guinea pig, 11½ ounces; injected 5 cc. untreated milk.

April 28. Weight of guinea pig, 13 ounces; injected 5 cc. untreated milk.

May 5. Weight of guinea pig, 14½ ounces; injected 5 cc. untreated milk.

July 13. Weight of guinea pig, 15 ounces.

Chloroformed and examined post-mortem. No lesions.

Guinea pig No. 185 ♀.

April 23. Weight of guinea pig, 10½ ounces; injected 5 cc. untreated milk.

July 13. Weight of guinea pig, 12 ounces.

Chloroformed and examined post-mortem. No lesions.

MILK FROM COW NO. 291.

This cow showed the presence of more or less tuberculosis on post-mortem examination, but had no visible affection of the udder.*

Guinea pig No. 186 ♂.

April 23. Weight of guinea pig, 13 ounces; injected 5 cc. untreated milk.

April 28. Weight of guinea pig, 13 ounces; no injection.

July 13. Weight of guinea pig, 15 ounces.

Chloroformed and examined post-mortem. No lesions.

Guinea pig No. 158 ♀.

April 18. Weight of guinea pig, 12 ounces; injected 5 cc. untreated milk.

April 23. Weight of guinea pig, 12½ ounces; injected 5 cc. untreated milk.

April 28. Weight of guinea pig, 13 ounces; injected 5 cc. untreated milk.

May 5. Weight of guinea pig, 14 ounces; no injection.

July 13. Weight of guinea pig, 17 ounces.

Chloroformed. Examination negative.

Tuberculosis was not found in any guinea pig in this last series of injections, notwithstanding the fact that the 4 cows furnishing the milk gave a high tuberculin reaction and are to all appearances in an advanced stage of the disease. Nos. 286 and 291 have been killed and found tuberculous (see Table v, p. 144).

The inference which may be drawn is the same suggested in Bulletin No. 3. It is that a careful inspection of all dairy herds which has for

* See No. 291, Table v, p. 144.—T. 8.

its object the detection and removal of all advanced cases of tuberculosis, and especially of cows with diseased udders, would probably exclude the sale of most infected milk.

In this connection it may be worth while to mention that in a recent inspection of over 800 cows which belong to different dairy herds of a large city it was found that between 5 and 6 per cent of the animals had defective udders. In the majority of cases it was evident that the udder trouble was due to present or past affections other than tuberculosis, but in the remaining cases this could not be determined during life.

These experimental observations further show that now and then the presumably mixed milk of dairies may contain enough tubercle bacilli to prove fatal to guinea pigs in two months.

STUDIES IN BOVINE TUBERCULOSIS WITH SPECIAL REFERENCE TO PREVENTION.

By THEOBALD SMITH.

[Plates 1-VI.]

Tuberculosis among domesticated animals, more particularly among cattle, has during the past few years received a large share of attention mainly because of the possible direct influence on human health. With this idea in the foreground the bearing of this malady on agricultural interests has been more or less obscured. As a result we have a great mass of publications on the hygienic aspect of tuberculosis and but very little on the prevention of this disease among cattle. Many of the more valuable contributions to our knowledge have been made in order to define more definitely what degree of tuberculosis makes an animal unfit for human food. This point of view, while bringing out now and then valuable facts, does not pay sufficient attention to the animal during life. What to do in order to reduce the high percentage of infection among living animals has been tacitly ignored in all but a few recent publications. It became evident to the writer on beginning these studies that this was, after all, the most important aspect of the serious problem of bovine tuberculosis. If the disease can be restricted and repressed among cattle during life the hygienic problem will take care of itself.

To attack tuberculosis as it exists at present is undoubtedly a most difficult problem and the conditions which tend to repress or to augment its further dissemination are very complex. No single measure, however sweeping, is likely to be successful. A number of details will have to receive careful attention and, in the end, the success will depend largely upon the amount of intelligent watchfulness constantly exercised in various directions by the stock owner. The wide dissemination and the localized intensity of this disease will require, above all, concerted action in attempts for its repression. Though a strictly bacterial disease and introduced into the body only by the tubercle bacillus, which is always derived from some preëxisting case of disease, tuberculosis differs, nevertheless, from most animal diseases in very important particulars. Its unknown beginnings in the body and its slow insidious march after it has once gained a foothold are responsi-

ble for the existence of a large number of tuberculous animals in all stages of the disease. In the earlier stages, while the disease is still restricted to a single focus, the animal is to all outward appearances in perfect health. It is only after the infection has invaded several cavities of the body or produced mechanical obstructions that it becomes manifest. The prolonged latency of the first stage of the disease with little or no discharge of tubercle bacilli raises the question what should be done with such cases. A comparison with some other infectious diseases makes the predicament all the clearer.

When an animal becomes infected with anthrax or with Texas fever the specific microorganisms begin to multiply at once. Within twenty-four hours in the case of anthrax, a few days to a week in Texas fever, the symptoms are fully developed and death or recovery speedily follows. There can be no question here concerning degree of disease or utility of the animal during the earlier stages. The infected and the non-infected are divided by sharp unmistakable barriers. In tuberculosis, on the other hand, the infected animal is practically well during the earliest stages of disease, and the disease may become stationary, possibly healed. This peculiarity in the nature of tuberculosis modifies to a certain extent the usual measures employed to repress an infectious disease. In certain diseases the necessity for the destruction of all infected animals becomes imperative, because the disease must be kept restricted and suppressed as soon as possible. The present wide dissemination of this disease and its prevalence among other domesticated animals, such as dogs, cats, horses, goats, and, above all, its prevalence among man, makes the complete extinction of this malady an unrealizable problem.

It is largely due to these peculiarities that tuberculosis has received so little attention until recent years. Its unrecognizable beginnings and slow insidious march in the body made it appear on the surface as a disease not of infectious origin, but as one in which inheritance played an important part. After the discovery of the true cause in the form of a bacterium (*Bacillus tuberculosis*) by Koch the conception that infection played the most important rôle has gradually gained a firm foothold. Without in any way wishing to eliminate the factor of heredity, the writer has based the statements in the following pages entirely on the principle now universally recognized, that without the presence of the tubercle bacillus there can be no tuberculosis. If it can be shown that the tubercle bacillus can be kept away from cattle by adopting certain precautionary measures the discussion concerning heredity would be useless. If, however, this should prove to be impossible the problems of breed, heredity, and environment, or, in other words, the accessory causes, will require renewed study.

In the following chapters matters of technical importance are introduced in order to form a basis upon which to found the practical suggestions given at the close. These suggestions must be considered as

subject to change as investigations progress. The prevailing ignorance upon certain important aspects of the subject makes the publication of even fragmentary researches justifiable at the present time.

PRIMARY DISEASE OF THE LUNGS AND PULMONARY GLANDS (AIR INFECTION).

According to published statements of most authorities and our own observations tuberculosis of the lungs is the most frequent of all the primary forms of this disease in cattle. The absence of disease elsewhere in the body, or the character of the pulmonary disease itself when associated with tuberculosis of other organs, leads directly to the inference that the bacilli must have entered the lungs in the inspired air. Infection through the air is, therefore, the most serious problem to be dealt with. It takes place when the tubercle bacilli have become thoroughly dried, so that they can be carried like particles of dust in currents of air and drawn into the lung tissue through the air passages.

In discussing tuberculosis of the lungs we have two forms to deal with: (1) Disease of the lung tissue proper with disease of the corresponding lymph glands, and (2) disease of the lymph glands of the lungs without any traceable lung disease associated with them. Tuberculosis of the lung tissue is in perhaps 99 per cent of the cases associated with tuberculosis of the corresponding lymph glands, while disease of the latter without visible lung affection is quite common in the early stages of the disease.

TUBERCULOSIS OF THE LUNGS.

(Plates I, II, III, and IV.)

The earliest disease in the lung tissue is quite regularly located in the large caudal lobes. The other lobes are occasionally found diseased, but there seems to be no place of predilection excepting the lobes mentioned.* Thus, in the herd described in the first article there were 19 cases of lung tuberculosis. Of these—

The large caudal lobes were affected in	16
They were affected exclusively in	11
Both caudal lobes affected in	6
Left caudal lobe alone in	5
Right caudal lobe alone in	5
Right cephalic lobe affected in	6
Right cephalic lobe affected exclusively in	3
Left ventral (with other lobes) in	1
Right ventral (with other lobes) in	1
Left cephalic (with other lobes) in	1

* For the nomenclature of the lobes of the bovine lungs as used in these pages, see Pl. I and II.

In another herd comprising 9 cases of lung disease only 2 had other lobes, in addition to the large caudal lobes, affected. In a third herd, in which pulmonary tuberculosis was found in 6 animals, all had foci in one or both caudal lobes and only 2 of these had other lobes affected. In most cases both caudal lobes are involved. In those in which but one is diseased the left seems to be more frequently attacked.

This predilection for the larger lobes seems to be due to mechanical conditions. The two main bronchi which supply these lobes branch off from the trachea at an acute angle (*see* Pl. III). The course of the current of air passing along the trachea into the terminal bronchi is nearly straight. But, what is of more importance, the caudal lobes are more expansible than the smaller anterior lobes. This is evident from the construction of the thorax, as well as from an inspection of the lungs themselves. The pleura is denser, often wrinkled, over these lobes when collapsed, a condition which indicates marked stretching during the expanded state of the lobe. More air passes into the lobes, and the current may be of greater velocity than that entering the smaller lateral branches. Tubercle bacilli suspended in the entering current are thus carried directly into the main bronchi and deposited in them or their ramifications within the caudal lobes. There they set up disease somewhere near the main bronchus. In fact, the larger number of primary foci are found in that portion of the lung tissue above or dorsad of the main bronchus, i. e., in the portion of the lung tissue which rests under the ribs at their vertebral attachment. This portion is shown as a shaded area in Plate I. The foci are rarely directly contiguous with the main bronchus or its large branches, and in case of many the writer was unable to trace any air tube into or near them.

The caudal lobes, as the chief primary seat of pulmonary tuberculosis, are not more susceptible than other lobes. Their infection is solely due to the fact that tubercle bacilli are deposited in them rather than in other lobes. Immunity of any region of the lungs is not deducible from the writer's observations. As the disease advances it seems to become equally destructive in all lobes attacked as soon as bacilli have found their way into them. If, in fact, the writer should predicate greater susceptibility of any region of the bovine lung, it would be the ventral and cephalic lobes, especially the former. For, basing ourselves on the condition of lungs far advanced in tuberculosis, it would seem that these smaller, less expansible lobes are more severely involved, when once attacked, than the caudal lobes. This condition would be analogous to that prevailing in human lungs.

Pulmonary tuberculosis differs from the sporadic forms of broncho-pneumonia in that the lesions of the latter, like the pneumonias of swine, are governed in their distribution by gravity. The ventral lobes, so rarely the seat of earliest lesions in tuberculosis, are affected first in broncho-pneumonia. Thence the disease spreads upward, over flowing into the cephalic lobes and the contiguous portions of the

caudal lobes. Another characteristic of broncho-pneumonia not found in tuberculosis is the symmetrical affection of both lungs. This is also a result of the gravitation of infectious matter. The difference is due to the mode of infection. The bacteria of swine plague and bovine pneumonia are speedily killed by drying, and hence dead when in a condition to be carried in the air. They are not inhaled in the living state, but are carried into the lungs in fluids and catarrhal secretions, and thus come under the influence of gravity in their distribution, as suggested. A comparison of these pneumonias thus indirectly supports the view that tubercle bacilli are inhaled.

After the development of a primary focus of disease, other foci may appear as a result of repeated infection from without. It is not an uncommon thing to observe a number of disease centers, evidently independent of one another, in the same lung or even the same lobe. These foci enlarge and invade neighboring tissue. Having reached a certain age, the necrotic tissue becomes softened and discharges into a bronchus. Thence the discharged masses, with the contained virus, may be carried along the air tubes into other regions of the lungs, or, perhaps into the throat, where it may be swallowed or thrown outward. This upward discharge of tubercle bacilli is indicated by the formation of tubercles on the mucous membrane of the air tubes. Primary disease in this situation has not been observed in any case examined.

The settling down and multiplication of tubercle bacilli in the lung tissue seems to be quite independent of any preëxisting disease of the lungs. In about 150 cases examined only a very few showed pneumonic lesions or bronchial affections, and in these few cases these changes were either due to the gravity of the tuberculosis or else to traumatism. Catarrh of the bronchial tubes was rarely observed, and then only locally, in connection with a tuberculous focus which was discharging its contents and causing irritation of the bronchial mucous membrane. On the other hand, the grafting of tuberculosis upon other lung affections, such as broncho-pneumonia, is equally rare. There are, it seems, no preëxisting pneumonic or bronchial affections which can be regarded as forming the entering wedge for tubercle bacilli. These seem to find in the healthy lungs a favorable soil at all times. Any special predisposition, if such really exist, must be sought for in other conditions than those of visible lesions.

TUBERCULOSIS OF THE THORACIC GLANDS.

There are many cases of tuberculosis which are due to infection through the inspired air, but which do not lead to any primary disease of the lungs. This begins in the bronchial and the mediastinal lymph glands, into which the lymph from the lung tissue passes. That there may have been in such cases very insignificant disease of the lung tissue itself is conceded, but it certainly eludes a very careful

search with the naked eye. In every case which came under the writer's notice, the lungs were thoroughly inspected and manipulated with the hands, then the air tubes slit open and the manipulation and inspection repeated. The primary affection of the lymph glands is in some cases made more evident by the advanced stage of the tuberculous process in the latter, with no accompanying disease of the lungs themselves.

Before giving any illustrations of this form of primary tuberculosis, a brief description of the system of thoracic glands attacked will not be out of place here, especially as they are not fully or even accurately described in the somewhat meager anatomical literature of this subject. While, for example, some writers on tuberculosis tacitly assume that the posterior mediastinal glands belong to the lungs, writers on anatomy consider them independent of the lungs, and only refer to the bronchial glands as strictly lung glands. The writer regards the posterior mediastinal glands as strictly pulmonary glands. This would be deducible from their relation to tuberculosis of the bronchial glands and of the lungs themselves. But there is a more cogent reason than this. A careful comparative examination of the bronchial and the posterior mediastinal glands will show that the pigmentation so characteristic of the bronchial glands with advancing age is identical in quality and quantity in the two sets of glands. In old cows the posterior mediastinals are as densely pigmented as the bronchials. Moreover, the general appearance of the glands of the two sets is the same, and not to be confounded with glands from other regions of the body.*

The bronchial glands (Pl. III) are situated on the trachea at or near the root of the bronchi of the different lobes. They might with equal reason be denominated tracheal glands. Of these three are regularly present.

The largest gland, the one most frequently involved in tuberculosis, and hence of most importance to us, is situated against the trachea in the angle formed by the left main bronchus with it (Pl. III, A). It is from 1 to 1.5 inches in diameter and of an irregular outline. It is firmly attached to these tubes and rests on the left pulmonary artery. The aorta arches over and conceals it.

The next largest bronchial gland is situated at the root of the right supernumerary bronchus on its ventral aspect and is firmly attached to the air tube (Pl. III, C).

The third quite small gland (right tracheal) is situated against the right side of the trachea near the bifurcation (Pl. III, B). It is rarely more than one-half inch in diameter. It is found in the incision between the right ventral and the right caudal lobe, entirely concealed by sur-

* Each lymph gland or group of associated glands in the bovine body has a general facies of its own, and a little well-directed observation will soon enable the pathologist to tell the region whence came the gland, as the anatomist recognizes bones and pieces of bones from a skeleton familiar to him.

rounding lung tissue. A fourth small gland is encountered in some animals in the acute angle formed by the bifurcation of the trachea (Pl. III, D).

It seems probable that the gland first described, and denominated in these pages as the left bronchial, receives the lymphatics ramifying about the bronchi (the peribronchial lymphatics). It is not improbable that it receives the lymphatics of the right as well as of the left bronchus. Its situation allows this, and its large size, compared with that of the right tracheal and its frequent infection, support this view.

Within the parenchyma of the left caudal lobe I have encountered in rare cases diseased glands situated along the main bronchus, between it and the pulmonary artery. They may be found in the healthy lung, but only after careful dissection and search, as they are very small. They do not seem to play any important rôle in tuberculosis, for they rarely obtrude themselves on account of enlargement. They may be called intrapulmonary glands.

The posterior mediastinal glands (Pl. IV) form a series or chain of glands situated in the dorsal or posterior mediastinum between the posterior aorta dorsally and the œsophagus ventrally. This chain extends from the pillars of the diaphragm as far as the right supernumerary bronchus. Some of the glands of this group may be felt *in situ* after one side of the thorax has been removed, but they are best studied by removing the lungs and heart with posterior aorta and placing the mass with the dorsal aspect of the lungs uppermost. After the aorta has been cut away and reflected these glands come into view embedded in more or less fat, the lower ones resting on the œsophagus and pillars of the diaphragm and loosely held in position by means of connective tissue and the serous membranes inclosing the mediastinal space. The number of glands in this chain visible to the naked eye varies more or less in different animals. The hyperplasia or enlargement following tubercular infection or inflammation of the lungs may perhaps bring some into view and thus account for the variable number.

The most important and most constant gland in this group is the extreme caudal member of the chain near the tip of the caudal lobes (Pl. IV, α). It is the largest gland of the chain. In the normal state it is a flattened elongated body, from 4 to 6 inches long, three-fourths inch broad, and one-half inch thick, rather firmly attached to the muscular pillars of the diaphragm (*g*), and extending some distance back (caudal) of the large ligament of the lungs (*i*). Its cephalic end is usually divided, the left lobe projecting farther toward the head than the right. It is highly probable that this gland consists of two glands fused together.

From this gland as a starting point the remaining glands seem to range themselves in two incomplete series on the right and left side of the mediastinal space. One series terminates in the left bronchial
 " other extends farther toward the head to the gland of the

supernumerary bronchus. The two chains may consist of three or four glands only, or there may be as many as seven.

The difference between the bronchial and posterior mediastinal glands in their relation to the lungs is this, that the former are firmly and snugly attached to the air tubes, while the latter rest upon the œsophagus, and are loosely connected with the lungs through the mediastinal portion of the pleura. Both, as stated above, are identical in appearance and in quantity and nature of pigment. It is probable that the mediastinal glands receive lymph vessels which ramify beneath the pleura (the subpleural lymphatics and their accessories), while the bronchial glands drain the immediate vicinity of the air tubes through the deep or peribronchial lymphatics.

If we turn to the literature of this subject we shall find that the views just expressed are quite different from those in current works on anatomy. As regards the functions of the posterior mediastinal glands the following statement may be quoted:

Die hinteren Mittelfeldrüsen haben ihre Lage an der Herzbasis unter der hinteren Aorta und am Schlund. Zwerchfell-, Mittelfell-, Schlund- und Herzbentel-lymphdrüsen entleeren sich in sie, ihre Verbindungen mit den Bronchialdrüsen ermöglichen den Abfluss.

Die oberflächlichen Lungenlymphgefäßen bilden unter der Pulmonalpleura ein Netzwerk, das in die vorderen Mittelfell- und Bronchialdrüsen seinen Abfluss nimmt, in diese der Bifurcation der Trachea eingefügten *Gland. bronchiales*, Lungenrüsen, ergießen sich auch die tiefen den Bronchialverzweigungen folgenden Lymphgefäße des Organes. (Article: Lymphgefäßsystem (Sussdorf), Koch's Encyclopädie der gesammten Thierheilkunde.)

According to this definition, the posterior mediastinal glands receive the lymphatics of the diaphragm, mediastinum, œsophagus, and pericardium only. If this were true the particles of pigment and the tubercle bacilli would have to escape from the lungs into the thoracic cavity first before they could come within the reach of the posterior mediastinal glands. Furthermore, this definition assumes that all lymphatics of the lungs empty into the bronchial and anterior mediastinal glands. The relation of the latter to the lungs is highly doubtful, if by anterior mediastinals are meant the small group of glands within the thorax under the first rib. These glands are not pigmented. They receive the lymph from the chain of lymph glands of the head and neck, and tuberculous changes in them are traceable in most cases to tuberculosis of the neck glands. It is not to be denied—it is, on the whole, highly probable—that the posterior mediastinal glands may drain the territories mentioned in the definition, but that they also stand in direct relation to the pulmonary lymphatics seems to the writer unquestioned.

A uniform nomenclature of these two sets of glands does not exist. While the terms "bronchial glands," "posterior mediastinal glands," are in general use, R. Schmaltz* is inclined to identify the posterior

* Topographische Anatomie der Körperhöhlen des Rindes. Lieferung 1, S. 20, 21.

mediastinal with his oesophageal glands. The bronchial glands are separated by him into those which are attached to the trachea outside of the parenchyma of the lungs (*glandulae lymphaticae cardiales s. tracheales posticae*) and those accompanying the bronchi into the lung tissue (*gl. lymph. bronchiales*).

In view of the confusion existing both as regards the name and the functions of the thoracic glands, a thorough reinvestigation of this subject, by reason of its important bearing on tuberculosis, is highly desirable. In the present article the writer maintains the position that not only the bronchial but also the posterior mediastinal glands as herein described are pulmonary glands, and that the anterior mediastinal glands at the root of the thorax are not connected with the lungs. A nomenclature of the functions would also be of far more service than one of position or location.

It has already been stated that tuberculous changes in the lung tissue are in almost every case accompanied by infection of the pulmonary glands, as might be anticipated from the functions of these glands. On the other hand, there are many cases of tuberculosis limited exclusively to the pulmonary glands. Combining these two groups of cases, it becomes evident that in almost every case of pulmonary infection the pulmonary glands are attacked. An examination of the tables on pages 139 to 144 shows this very clearly.

If we restrict our attention to the exclusively glandular tuberculosis some interesting facts are at hand. In the 53 cases of tuberculosis from one herd, 47 had been infected through the lungs. Of these, 27 had gland disease only, the lungs being free. A still closer analysis shows that in 5 cases the mediastinals alone, in 5 the bronchials alone, were diseased.

Among the bronchial set the left bronchial is most frequently involved. Among the mediastinals the large caudal gland is the favored seat of tubercles. This gland, on the whole, is perhaps more often found diseased than any other thoracic gland, and hence any other lymph gland in body. It should never be overlooked in searching for the primary seat of disease. In the 53 cases of the herd referred to, this gland was diseased in 34. The left bronchial was diseased in 24 cases only. The other glands of either group are not infrequently affected at the same time, but there is no regularity in this respect. In advanced cases all thoracic glands are diseased. In other herds a similar restriction has been observed by the writer, provided the disease was not too far advanced.

In 9 cases from one herd, 3 had tuberculosis of thoracic glands only.

In 17 cases from another herd 3 had tuberculosis of glands only.

In 8 cases from a third herd, nearly all of which were advanced cases, 1 had gland disease only.

Finally, in 34 cases from a fourth herd 11 had the thoracic disease restricted to the glands, but of these 10 had tuberculosis of other organs in the thorax.

In order to get some information from carefully performed autopsies recorded by other observers, I looked over the brief protocols published recently by Röckl,* Schütz, and Lydtin.† These observers examined quite a number of animals, many of which had been recognized as tuberculous before the application of the tuberculin test. These do not concern us here, since they represent more or less advanced tuberculosis of the lungs. One series of 12 fattened cows from the same herd is of interest, since they correspond closely to the animals described in this bulletin.

Of these 12, one may be thrown out as doubtful, since some glands were not examined. Of the remaining 11, one was free from tuberculosis, the rest infected.

The 10 cases may be tabulated as follows:

No.	Bronchial glands.	Mediastinal glands.	Lungs.	Mesenteric glands.	Portal glands.	Udder.
1	+	—	—	—	—	—
2	+	+	—	—	—	—
3	+	+	—	—	—	—
4	—	+	—	—	—	—
5	—	+	+	—	—	—
6	—	+	+	—	—	—
7	—	—	+	—	—	+
8	—	+	+	+	—	—
9	+	+	—	—	+	—
10	—	—	—	+	—	—

From this table it will be seen that in 4 the thoracic glands only were affected. Five had pulmonary tuberculosis, and of these all but 1 had disease of the related glands. Infection by way of the lungs is indicated in 90 per cent of the cases.

In another series of 19 animals from the same dairy and in good condition 12 were found infected; 4 had gland tuberculosis only, the remainder pulmonary as well as gland tuberculosis.

Siedamgrotzki and John[‡] report upon a miscellaneous lot of 40 animals, of which 23 were found tuberculous. Of these only 2 had the disease restricted to the thoracic glands. In most other cases the lungs and thoracic glands were diseased. In a few no mention is made of the thoracic glands. This may be due to an oversight.

Fischöder, § in an analysis of 600 cases of tuberculosis observed at one of the German abattoirs, states that 599 had tuberculosis of the thoracic organs (infection through the air). In 210 of these, *i. e.* in more than one-third of the total number, only the pulmonary glands were involved.

* Arbeiten aus dem Kaiserl. Gesundheitsamte, VIII (1892), p. 1.

† *Loc. cit.*, p. 48.

‡ Deutsche Zeitschrift für Tiermedizin, XVIII (1891), p. 66.

§ Zeitschrift f. Fleisch- u. Milchhygiene, IV (1894), p. 8.

This preponderance of gland over pulmonary disease in the earliest stages of tuberculosis has not been pointed out with any emphasis as an important regularly occurring phenomenon. When the writer several years ago began his observations on tuberculosis for the purpose of studying the modes of infection, the disease of the thoracic glands was noticed by writers as something casual and accidental, to be classed with the numerous other freaks of tuberculosis. The necessity to find some even slight lesion to account for the tuberculin reaction has led recently to more careful examination of the cadaver and a better knowledge of the disease itself.

In summarizing the relation of the thoracic glands to tuberculosis we may safely lay down the general statement that in incipient or stationary disease the bronchial and posterior mediastinal glands play a more important rôle than any other set of glands in the body. The importance of a careful examination of them, especially of the most caudal mediastinal and the left bronchial gland, in determining the presence of tuberculosis is, therefore, self-evident.

The primary infection of the pulmonary glands and of other glands of the body is not accepted by all pathologists. Some claim that there must be lesions at the point of entry, in the lungs, for example, which are not recognizable, owing to their minute size. This subject will be more fully discussed farther on. Meanwhile the primary infection of lymph glands is accepted in this article as frequently occurring and in fact as a characteristic of bovine tuberculosis.

The penetration of tubercle bacilli into and through the lung tissue and their final lodgment in the lymph glands is probably due to the nature of the bacilli themselves. They are in a thoroughly dry condition before they can be inhaled. Passing through the trachea and into the bronchial tubes with the current of air, they are deposited, seized by some cell and carried into and along the lymph channels into some pulmonary gland in the same way as the pigment is carried. Why they do not multiply at the place of deposit is probably due to the inert state of the dried bacilli. Before they have assumed the vegetative state, they have been carried as harmless foreign bodies into the lymph glands, sharing thus the same fate as the inert particles of pigment. They manifestly are unable to call forth any chemotactic activity on the part of the body cells or to produce any so-called local irritation until they have begun to multiply. The dried state and the proverbially slow growth of tubercle bacilli subsequently may thus account for the penetration of tubercle bacilli far into the body before they begin to cause tuberculosis. In other regions of the body, such as the intestines, the tubercle bacilli can not be considered as dried, and here the simple inert character of the organism may account for its being carried into the mesenteric glands without producing recognizable lesions of the mucous membrane.

The infection of the pulmonary glands in the early stages of tuber-

culosis is in many respects a safeguard both to the affected animal and the rest of the herd. Tuberculosis of the lungs proper not only appears to be more destructive, but, by virtue of the situation of the focus of disease, a discharge of tubercle bacilli will take place sooner or later which may endanger other portions of the lungs or the throat, and which is always responsible for extensive secondary infection and great enlargement of the lymph glands, especially the mediastinal. The foci, primarily formed in the lymph glands, spread but slowly, and in many instances all tendency toward the dissemination of the lesions appears to be checked.

A question of much practical consequence presents itself here in regard to the effect of repeated infection. That cattle may be infected more than once is self-evident when we consider the chances for such infection. The writer has seen a few cases in which two independent infections of the large mediastinal gland could be assumed from the appearance and location of the disease foci. Again, the occurrence of a number of independent foci in the lungs is frequently observed. It might be supposed that the occurrence of disease of self-limited extent following infection might favorably influence the organism by a kind of immunizing or vaccinating process to resist equally well subsequent infection. This view must be regarded as true within certain limits, but the particular place where the second infection became located would to a certain extent modify the result. Thus, two infections of the thoracic lymph glands are less harmful than when the second infection lodges in the lung tissue itself, for this organ is more vulnerable and the bacilli more likely to become diffused. When, therefore, the lymph glands have become more or less impaired by disease the powers of absorption become less active, and future infections are likely to lodge in the lung tissue itself, because the bacilli may not be carried off with that promptness which characterized the working of the normal uninjured lymphatic system.

The practical application of these facts is obvious. The more frequent the infections the more rapid the disease and the speedier the danger of the one case to other animals. The fewer the tubercle bacilli in the air the more reduced the danger. It is highly probable that cattle may under conditions inhale a few tubercle bacilli without permanent injury. They may become absorbed into the lymph glands and there the disease focus remain small and finally heal. The writer has seen the large caudal gland of the posterior mediastinum extensively cicatrized by old completely healed tuberculous foci. Such changes will, of course, not be found excepting where the tubercle bacilli were originally deposited. When the disease has once extended beyond the confines of the primary focus it has acquired sufficient momentum to continue its destructive action uninterruptedly. The importance of reducing the amount of infection in a herd by all possible means and keeping it permanently reduced is one necessary condi-

tion requisite for the successful eradication of tuberculosis. Even if tuberculin does not reach every mild case, the peculiar nature of the affection in virtue of which a slight amount of infection may be overcome bridges over the gap which may have been left by turberculin.

The important facts bearing on tuberculosis of the lungs in cattle are briefly as follows:

(1) Primary infection through the air is more frequent under existing conditions than any other mode of infection.

(2) The early stages of the disease may consist of glandular affections only.

(3) The extent and rapidity of the disease depend at least in part upon the number of tubercle bacilli inhaled either within short or long periods of time.

(4) Tuberculosis of the lungs is not necessarily associated with any other recognizable lung affection as a preëxisting, favoring condition.

PRIMARY TUBERCULOSIS OF THE LYMPH GLANDS OF THE HEAD AND NECK.

(Plates v and vi.)

These glands are so frequently the seat of primary infection that they demand careful consideration. Before discussing their relation to the disease in detail we will review briefly their location and function. These glands are in pairs and symmetrically situated on both sides of the body. They comprise the submaxillary, the parotid, the retropharyngeal, and the postmaxillary glands.

Each submaxillary lymph gland or group of glands (Pl. vi, C) is situated on the inner aspect of the lower jaw, in front of the angle. The larger gland is hidden within the large anterior head of the submaxillary salivary gland (*f*) and covered with some fat. After the skin is removed a drawing away of the salivary gland from the bone exposes at once the gland, which has the usual flattish shape and is about 1.5 inches long. The other glands, if present, are situated nearer the angle. It receives the external lymphatics of the nose, lips, and cheeks, and the lymphatics of a portion of the mucous membrane of the nose and cheeks, and of the anterior portion of the tongue. It drains into the retropharyngeal gland.*

The parotid gland (Pl. vi, A) is situated quite superficially. If a line be drawn from the external meatus of the ear to the lower border of the orbit of the eye the upper end of the gland touches this line and is located about 1 inch in front of the meatus. The gland is about 1.5 to 2 inches long and is partially concealed by the anterior margin of the parotid salivary gland. This gland receives lymphatics from the ear, the parotid salivary gland, the temporal region, and the pharynx.

* The information here given concerning the respective territories drained by these glands is taken from Koch's Encyclopædia.

The most important pair of glands, so far as tuberculosis is concerned, are the retropharyngeal glands (*Gl. tracheales s. cervicales superiores*). These are somewhat larger than those just described. Their situation is most readily understood by examining Plate V, which represents the head of a Jersey cow sawn through in the median plane. The individuals of this pair of glands are in close proximity to each other and situated directly under the mucous membrane, covering the dorsal or posterior wall of the naso-pharynx (the passage leading from the nasal cavities into the œsophagus). Each rests laterally on the hyoid bone. Besides receiving the efferent vessels of the two sets of glands described they receive the lymphatics of the caudal region of the nasal cavities, including those of the pharynx.

In close proximity to these glands are another set which do not appear to figure in text-books; at least the writer has been unable to identify them with descriptions given. They are situated under the caudal or posterior margin of that portion of the submaxillary salivary gland which extends along the caudal margin of the parotid gland upwards towards the ear. The glandular mass is irregular and usually separable into two or three independent glands. They are denominated here postmaxillary (Pl. VI, B).

The tonsils are situated under the mucous membrane of the posterior region of the nasal passage. The opening is shown below the soft palate as a black spot in Plate V.

One or the other of the four pairs of glands described and the tonsils represent the seat of primary infection in many cases. An examination of the synoptic tables on pages 139 to 144 shows that the entire disease is not unfrequently limited to these glands.*

Of the four pairs, the retropharyngeal are by far the most frequently diseased. This is due primarily to the important position of this pair, and secondarily to the fact that it receives the lymph from the other pairs, excepting, perhaps the postmaxillary, into which it may drain. Hence it is uncommon to find any of the other glands affected without tuberculosis of these glands. On the other hand, they are diseased in many cases when none of the others are involved. Although both glands are usually diseased, it is not uncommon to find but one involved. In the tables referred to above one cross indicates disease of but one gland, two crosses of both glands.

The submaxillary glands are rarely diseased, hence any palpation or inspection of the intermaxillary space for enlarged glands is likely to prove fruitless in most cases. The parotid glands are also rarely infected primarily. A swelling or tumor in front of one or both ears is strongly suggestive of tuberculosis of these glands. Lastly, the postmaxillary glands are also infrequently diseased. Any enlargement causes a swelling to appear behind the lower jaw.

* Whether the postmaxillary glands may be primarily diseased or whether they receive the infection from the retropharyngeal glands remains to be determined.

The tonsils are less frequently diseased than one might suppose from their situation. The largest percentage of tonsillar disease was found in herd V (Table IV, p. 143). In one animal it appears to have been secondary to tuberculosis of one of the retropharyngeal glands. A small fistulous opening from the enormously enlarged gland was found in the roof of the posterior nasal passage. The tonsil of the same side appeared to have been only recently infected.

In tracing the channels of infection it is of considerable importance to determine how far tuberculosis of the retropharyngeal glands may be due to tubercle bacilli inhaled, or to such as are ingested with the food. Writers are in general agreed that disease of these glands is the result of food infection. It is not improbable that bacilli inspired in the air are frequently deposited in the nasal passages with the dust. Whether such bacilli are absorbed from the surface of the normal mucous membrane is questionable. In the mouth, on the other hand, the opportunities for slight laceration of the mucosa are more numerous, and hence the chances for infection of the lymph glands better. Moreover, the tonsils may be active in the absorption of particles through the agency of migrating leucocytes. If this be so it is strange that so little tuberculosis of the tonsils is found with so much infection of the retropharyngeal glands. Perhaps here, as in the lungs, the absorption and passage through the tonsils into the lymph glands goes on very rapidly, so that opportunity for multiplication is not given until the bacilli have reached the lymph glands.

Besides the chances for direct infection from without these head glands may also be secondarily infected with tubercle bacilli, which are coughed up from the lungs when the disease in the latter organs is far advanced and the broken-down tissue is discharging into some air tube.

If, as seems very probable, infection of the glands of the head is to be ascribed largely to those tubercle bacilli which are taken into the mouth with the food, the source of the bacilli may be looked for in the milk or in the tuberculous discharges from nose and vagina, which cattle may take into their mouth when they lick one another. The food may also be infected with these discharges.

Tuberculosis of these glands always forms a prominent feature of the bovine disease. In Herd I (Table I, p. 139) the retropharyngeal glands were diseased in 9 out of 60 animals. In 5 of these no other focus of disease could be found. Of the remaining four cases two were probably secondarily infected with tubercle bacilli discharged from softened foci in the lungs. In Herd II (Table II) the percentage of cases with tuberculosis of the glands of the head is very high. An analysis of the lesions found in the lungs indicates that perhaps a few may have been infected secondarily from bacilli discharged from ruptured foci in the lungs. Again in Herd V (Table IV) the infection of the lymph glands of the head stands out prominently.

Tuberculosis of the retropharyngeal glands may become serious by

impeding respiration and deglutition. An examination of Plate V will show that any enlargement of these glands will diminish the size of the pharynx. When they become very large and are associated with enlarged, diseased tonsils, the difficulty in breathing may become very great by the encroachment of the passage from two directions. Case H, page 143, is a good illustration of this condition. Though the animal breathed with difficulty and was emaciated, the only serious tuberculous lesions existed in the throat glands and the tonsils. Those in the chest were trifling. In cow No. 292 (Table V) one of the retropharyngeals measured 5 by 4 by 3 inches, the dimensions of the normal gland of the opposite side being $1\frac{1}{2}$ by 1 by $\frac{1}{4}$ inch, or only one one hundred and sixtieth of the volume of the tuberculous gland. A minute opening from this gland through the mucosa of the roof of the nasal passage was found, through which putrefactive bacteria had entered, and the disintegrated tuberculous tissue was discharging outward. The enormous gland had greatly encroached on the space of the pharynx and the epiglottis was displaced so as to appear obliquely placed. A serious result of this condition was the presence of small pneumatic foci in the lungs, due to the aspiration of foreign particles. The impaired swallowing permitted such particles to enter the trachea. In the minute plugged air tubes of the affected lobules, vegetable fibers were found completely encrusted with leucocytes. Only traces of tuberculosis were found in the lungs and one gland in the mesentery was affected. The visible signs of disease in this animal may thus be attributed exclusively to the enormous throat gland.

The comparative frequency of tuberculosis of the glands of the head in the herds examined by the writer does not appear to be paralleled in other countries. The latest most extensive figures of Fischöder include only 6 cases of tuberculous "cervical glands" out of 600, or but 1 per cent. This small percentage it is hard to account for.

PRIMARY TUBERCULOSIS OF THE MESENTERIC GLANDS, THE INTESTINES, AND THE LIVER.

The glands within the layers of the mesentery are very frequently the seat of tuberculous lesions. A glance at the tables is sufficient to show this. In nearly all cases the evidence is pretty positive that the tubercle bacilli were absorbed from the contents of the intestines and not from the circulating blood. They must, therefore, have passed through the stomachs with the food and resisted the destructive action of the digestive process. When we come to analyze this mode of infection more minutely the source of the infectious material is not always recognizable with certainty, since disease of the mesenteric glands is rarely seen by itself, other foci being in almost every case associated with it. In the cases summarized in Tables I to V, only one animal is shown to have exclusively disease of the mesenteric glands and of the

liver (No. 333 in Table I). In all the remaining cases there are tuberculous foci either in the lungs themselves or in pulmonary lymph glands, which indicate infection through the inspired air as well. These cases range themselves in two groups, those in which the lungs themselves are affected, and those in which only the pulmonary glands are diseased. In the former group of cases the tubercle bacilli may have been coughed up from the disintegrating foci in the lung tissue, swallowed and absorbed from the intestines into the mesenteric glands. In the latter group this could not occur because the tubercle bacilli are locked up in the lymph glands of the thorax. In this group, therefore, the infection of the digestive tract must be regarded as independent of the lung infection.*

A careful examination of the autopsy notes of herd I (pp. 31 to 59) will show that even in many cases of pulmonary disease, either the lesions are not far enough advanced to account for the disease of the mesenteric glands, or else the stage of disease in the latter is as old as, or perhaps older, than the lung disease. Hence we may safely affirm that in many cases of tuberculosis the animals have both inhaled and ingested the tubercle bacilli, thus starting at the same or at different times, two independent foci of disease.

Tuberculosis of the mucous membrane of the intestines is very rare. The writer very carefully examined the digestive tract of the animals included in Table I without finding tuberculous changes in the mucous membrane, with the exception of one advanced case (No. 338), in which there was evidently an abundant discharge of tubercle bacilli from the lungs. In this case, which was near the point of death, all Peyer's patches of the small intestine were extensively infiltrated with tubercles. (See p. 124 for worm tubercles vs. genuine tubercles).

In the animals included in the other tables, no systematic examination of the intestines was made, i. e., the tube was slit up throughout its extent in only a few cases, but the serous surface was more or less carefully inspected to note any signs of disease in Peyer's patches.

The presence of tubercle bacilli in the liver may manifest itself by tuberculous foci in the liver tissue, or what is more common, by tuberculosis of the lymph glands situated in the portal fissure, and denominated portal glands in the tables. An inspection of these will show, out of 123 tabulated cases, 29 with tuberculous portal glands. Of these, 12 have deposits in the liver at the same time. Three have disease of the latter without corresponding infection of the glands. Hence, in determining the presence or absence of infection of the portal system the portal glands must be carefully searched for tubercles.

Tuberculosis of the liver is probably, in most cases, a result of food infection. This is made evident by the fact that in most cases of liver tuberculosis the mesenteric glands are also diseased. In the 29 cases

*Nos. 346, 348, 355, 358 in Table I; Nos. 599 in Table II; J in Table III.

tabulated all but 4 are associated with disease of the mesenteric glands. Of these four one is associated with disease of throat glands, also indicative of food infection. In the three cases remaining the disease may be secondary to lung disease in one and primary in two.

The sources of the bacilli which enter the portal system may be several. The bacilli may be absorbed directly from the mucous membrane of the intestines into the venous radicles of the portal system. They may also pass from some focus in the mesenteric gland into the portal system. In either case the original source is the contents of the intestines. Primary infection of the liver during fetal life will be discussed further on.

OTHER ORGANS WHICH MAY BE PRIMARILY DISEASED.

We have seen that the primary foci of infection are in the great majority of cases situated (1) in the lungs or the bronchial and mediastinal glands, and (2) in the glands of the neck and head, the mesenteric glands, the portal glands, and in the substance of the liver. The first indicate infection through the inspired air, the second through the food. Of the other seats of primary disease only the udder and the genital organs (the uterus) come into consideration. Bang* is inclined to believe that tuberculosis of the udder does now and then appear primarily in animals which are in very good condition. A case recently examined is of interest in this connection.

A large Jersey cow, registered, 6 years old, kept in a large herd under very good sanitary conditions, has had some trouble with the right half of the udder for two years. During this time only the anterior quarter of this side was milked. At the beginning of this year (1894) she gave birth to a calf, but "did not clean well." She was killed in April, although in very good condition at the time if we except the vaginal discharge. The affected half of the udder was uniformly larger than the secreting half and very firm. The autopsy showed the following conditions:

The right half of the udder with the exception of a narrow anterior segment was involved uniformly in tuberculosis. The cut surface had a mottled pink and pale yellowish appearance throughout. A few circumscribed areas were somewhat further advanced in caseation, for they appeared more uniformly opaque, yellowish, the pinkish element having disappeared. No old focus of disease could be found in the udder from which a dissemination of the virus into the surroundings could be inferred to have taken place. Cover-glass preparations made by gently scraping the cut surface and rubbing the material so obtained on slides showed many tubercle bacilli. Sections of the organ hardened in alcohol were equally conclusive as to the nature of the affection. Every acinus was the seat of one or more tubercles. In some ^a

* Deutsche Zt.-chr. f. Thiermed., xi (1884), p. 45.

little of the secreting epithelium was still left; in others it had been completely crowded out by the neoplasms. In only a small percentage of the tubercles was the center necrosed. Tubercle bacilli were very abundant, both in the numerous giant cells and in the peripheral zones of each tubercle. The pubic lymph glands in this animal were very much enlarged and contained minute, isolated, and confluent necrotic foci. Tuberculosis was detected in other organs, as shown in the following post-mortem notes, dictated by the writer:

Both retropharyngeal glands contain small foci of tuberculosis of recent origin. In both principal lobes of the lungs there are a considerable number of foci, involving each one or more lobules. Some are uniformly necrotic, but not softened; others are composed of groups of isolated tubercles. In the smaller lobes a small number of similar foci exist. The large mediastinal gland is 4 by 2 by 3 inches in size. It contains large yellowish, partly calcareous foci. Left bronchial gland, about 2 inches in diameter, in the same condition.

A whitish pasty exudate in one horn of the uterus, the walls of which are nearly half an inch thick and contain small caseous foci. Tuberculosis determined in sections of hardened tissue.

This case is peculiarly interesting on account of the extensive tuberculous infiltration of the udder. Was it infected from without or through the blood? The most reasonable explanation seems to be the latter. The disease in the lungs, the uterus, and the udder was, according to microscopic examination, in about the same stage. That of the mediastinal glands was in a more advanced stage. The probability is that, during the violent disturbance occasioned by the birth of the calf, tubercle bacilli were carried into the circulation from the older focus in the mediastinal glands. They lodged and subsequently multiplied in the organs mentioned. The uniform diffusion of the disease in the udder might be explained by a rapid disintegration of some small foci and the downward dissemination of the tubercle bacilli through the milk ducts.

Another hypothesis entertained by the writer was the infection of the udder from without through the milk ducts. This would appear well nigh impossible in an udder milked twice a day, by which process all entering tubercle bacilli would be washed out promptly. Considering, however, that in this animal the affected quarter had not given milk for two years, we can not rely on the washing out of the ducts in this instance. Another question naturally arises in this connection, whether tubercle bacilli are capable of growing along a milk duct in competition with other bacteria. We know that they are often present in enormous numbers in necrotic tissue, but whether they may live in the secretions of a mucous surface so as to become disseminated is open to serious doubt when we bear in mind their peculiar parasitism.

Another mode of entrance would be through injuries of the udder itself. If the injury were deep enough the bacilli might be deposited directly in the gland tissue, but a mere abrasion is hardly a suitable place of entry. In deep lacerations the tubercle bacilli would very probably have to compete with pyogenic bacteria introduced at the same time.

The whole subject of udder tuberculosis needs more careful study, especially with reference to the question of primary infection. This question is of great importance because a primary infection would be all the more dangerous since it might be associated with an otherwise healthy organism and thus ward off suspicion until much damage has been done by the milk.

Primary infection of the uterus from without could hardly take place excepting during copulation. The bull may carry tubercle bacilli from one cow to another without necessarily being diseased himself, as in the case of tuberculosis of the uterus associated with vaginal discharge. In case the genital organs of the bull are affected the transmission of tuberculosis to the cow is easily understood. Nevertheless, primary tuberculosis of the uterus does not appear to be very common. In most cases with diseases of this organ, the infection may be traced to some other preëxisting focus in the same animal. Local infection of the bull from the cow seems to be comparatively rare in spite of the fact that tuberculous lesions of the uterus associated with the discharge of tubercle bacilli in catarrhal secretions are not infrequent. Even tuberculosis of the vagina and vulva have been reported.*

An interesting case of probable infection through the genital organs is No. 634, in Table II. A bull calf about 8 months old, which had given a reaction after the injection of tuberculin, was killed and carefully examined. Only one focus of disease was found. The pubic glands were enlarged and studded with yellowish tubercles. Since there was no other primary focus in the body, no indication of generalized infection, the only explanation left was the contraction of the disease from some cow with tuberculous uterus. The bacilli were absorbed from the external genital organs and deposited in the corresponding lymph glands.

A case of primary tuberculosis of the penis in a bull was reported by A. Eber† several years ago.

THE RELATION OF THE LYMPHATIC SYSTEM TO THE PRIMARY SEAT OF TUBERCULOSIS IN CATTLE.

In the preceding chapter it was pointed out that a large proportion of the cases in which tuberculosis was either in an incipient stage, or else restricted to a single focus, the lesions were found in the lymphatic glands, which drain certain organs exposed to infection and not in these organs themselves, and it has been tacitly assumed that the tubercle bacilli passed through these organs into the respective lymph glands without leaving any trace of disease behind.

Thus in infection by way of the lungs the tubercle bacilli pass through the tissues of the parenchyma, and are carried in the lymph

* Deutsche Zeitschrift f. Tiermedizin, xviii (1891), p. 135.

† Loc. cit., p. 188.

channels to the corresponding lymph glands. In infection by way of the intestines, the tubercle bacilli pass through the mucous membrane into the mesenteric glands, or by way of the portal system, into the liver. The same may be said of the mouth and nose. The bacilli deposited on the mucous membrane are carried into the lymph glands without causing any visible lesion of the mucous membrane. These conditions hold for only a portion of the cases which come under observation, for in the remainder the parenchyma of the organs is involved in the disease. In some of these cases, however, there still remains the question whether the earliest lesions may not have been limited to the lymph glands.

That tubercle bacilli may pass into the lymph channels of organs without leaving in the latter any trace of disease was first distinctly pointed out by Weigert* with regard to tuberculosis in children. He called attention to the fact that tubercle bacilli may enter the mouth, the lungs, and the intestines, and affect the respective lymph glands without first causing disease of these organs. In case of the lungs, secondary infection may take place later on from the lymph glands by contiguity. He furthermore pointed out that scrofula in children is explained by the absorption of tubercle bacilli from the mouth and their retention and multiplication in the glands of the neck. In adults the reverse is usually true. The parenchyma of the organs becomes affected first, and the lymph glands afterwards.

Bollinger† likewise admits the absorption of tubercle bacilli without the appearance of a local lesion.

Veterinary pathologists have also called attention to this peculiar behavior of tubercle bacilli. Hartenstein‡ speaks of the lymph glands as excellent reagents for the presence of tubercle bacilli in the body Eber-Johne§ and Rieck|| also refer to the restricted localization of tubercle bacilli in the lymph glands. Baumgarten,¶ on the other hand, maintains the position that tubercle bacilli can not pass any organ or mucous membrane without causing tuberculous lesions at the place of entry.

Tangl,** working on this theme at his suggestion, comes to the same conclusion. The latter found that in guinea pigs the application of tubercle bacilli to the uninjured conjunctiva produced at first local and subsequently generalized tuberculosis. In rabbits, on the other hand, neither local nor subsequently general tuberculosis was produced. The

* Jahrbuch für Kinderheilkunde, XXI (1884).

† Tenth International Congress at Berlin, 1890.

‡ Archiv f. wiss. u. prakt. Thierheilkunde XVI (1890), S. 354.

§ Encyclopädie d. gesamt. Thierheilkunde (Article Tuberculosis).

|| Archiv f. wiss. u. prakt. Thierheilkunde, XIX (1893), S. 1.

¶ Pathologische Mykologie. Arbeiten a. d. path-anatom. Institut zu Tübingen. I. Ueber experimentelle congenitale Tuberkulose.

** Centrblatt für allgemeine Pathologie, I (1890), S. 763.

experimental observations of Dobroklonski* do not appear to give much support to Baumgarten's view. He fed guinea pigs with a few drops of pure cultures of tubercle bacilli and studied the mucous membrane of the intestines at different intervals. He found that, although the epithelium remained intact, the solitary and agminated follicles, or Peyer's patches, soon began to show signs of disease. The tuberculous changes might also, though very rarely, take place in the subepithelial layer of the mucosa. The rapidity with which the bacilli penetrated into the lymphatic system was demonstrated by the fact that tubercle bacilli were found as early as the fourth day in the mesenteric glands, and that the tubercles appeared as soon in these glands as in the lymph follicles of the intestine.

Whichever view we may adopt, the fact remains, that in a very large number of cases of bovine tuberculosis in the earlier stages a most careful scrutiny reveals only disease of the lymph glands. If the bacilli do cause disease of the lungs on their way to the thoracic glands the lesion remains invisible to the naked eye and heals up. The same may be said of the intestines and mucous membrane of the mouth and nose.

DISSEMINATION OF TUBERCLE BACILLI WITHIN THE BODY FROM THE PRIMARY FOCUS.

After the lodgment of tubercle bacilli in the primary focus, where their multiplication stimulates the formation of the neoplasms or tubercles peculiar to this malady, the disease may after a time become stationary and the tuberculous products finally undergo calcification. In most cases, however, the disease, after being purely local for a time, and not disturbing the normal functions of the animal to any recognizable degree, spreads from the original focus more or less rapidly and invades the more organs and structures the longer the life of the affected animal. The courses which the virus takes in moving from the primary focus or foci to establish new centers are subject to much puzzling variation and have been the subject of much investigation and speculation. The development of the meat-inspection service in Germany has stimulated discussion in this field perhaps more than in any other connected with bovine tuberculosis.† In general the tubercle bacilli may be disseminated either by the lymph or the blood channels or by both combined. To these may be added the dissemination by contiguity, which is probably responsible for most forms of tuberculosis of the serous membranes (pearly disease). Inasmuch as this is a very important type of the disease we will discuss it by itself first.

* Archives de Médecine expérimentale, 11 (1890), p. 253.

† Those who would pursue this phase of the subject are referred to the writings of Ostertag, Schmidt-Mühlheim, Hartenstein, and those of Carl Weigert for human tuberculosis.

TUBERCULOSIS OF THE SEROUS MEMBRANES (PEARLY DISEASE).

This form of the disease, if such it may be justly called, has always created more or less interest, largely owing to the very remarkable growths produced on parts of the body at once exposed to view when the carcass is opened. Formerly it was customary to consider tuberculosis of the organs and tuberculosis of the serous membranes (pleura, pericardium, peritoneum) as more or less distinct, although associated forms, of disease. This view is gradually giving way as our knowledge of the progress of the disease in the body is becoming more thorough. Rieck,* with reference to this same subject, says that former statistics which maintain that there is a large number of cases of tuberculosis of the serous membranes exclusively must rest upon partial examination. He himself states that in all of the many cases examined by him at the Leipsic abattoir pearly disease was associated either with tuberculosis of the bronchial, mediastinal, or mesenteric lymph glands.

So far as the writer's observations have gone they fully confirm Rieck's statement that tuberculosis of the serous membranes is not primary. In the 53 tuberculous animals of the herd in Table I tuberculosis of the serous membrane was observed but three times. In one case (No. 338) it was associated with widely disseminated and severe lesions of the lungs and lymphatic apparatus. In the second case (No. 314) the costal pleura was affected by contiguity from a large pulmonary focus, and in the third case (No. 343) the abdominal diaphragm was studded with tubercles which were secondary to disease of the thoracic glands.

In the cases presented in the other tables tuberculosis of the serous membranes is also associated with glandular tuberculosis.

The very small percentage of cases in which the serous membranes were found diseased by the writer, and the absence of any primary infection of these membranes, are facts significant in confirming Rieck's statement that tuberculosis of the serous membranes is quite a secondary phenomenon and does not deserve the attention which has been accorded to it up to the present. It is probably never present in incipient cases or in such as have been healed or become stationary in the earliest stages. If tuberculosis of the pleura or peritoneum is found it should be regarded as an indication that further search be made, especially in the thoracic and the mesenteric glands, for the seat of primary infection.

In the many isolated cases of advanced tuberculosis examined during the past five or six years by the writer tuberculosis of the serous membranes was never absent. Sooner or later these membranes become the seat of a more or less extensive tubercle eruption. This may occur when the disease travels by contiguity, as from lung tissue to pulmonary pleura, and thence to the costal pleura, to which the diseased pulmonary pleura soon become adherent. Or it may be due to a

* Archiv f. wiss. u. prakt. Thierheilkunde, xix (1893) S. 1.

backward flow of lymph, an occurrence confirmed, in the writer's opinion, by case No. 343, p. 48. In this animal there were several tuberculous foci in the lungs but no pleural tubercles. The posterior mediastinal and the bronchial glands were at least as large as fists (one mediastinal 8 by 5 inches) and consisted mainly of sacs of partly cheesy, partly puriform matter. The large caudal mediastinal gland was least affected. Curiously enough the abdominal aspect of the diaphragm was studded with a considerable number of flattish, rather large, sessile, tuberculous masses. An adhesion between the diaphragm had led to the formation of a similar mass on the capsule of the liver. Between this and the diaphragm the adhesion had expanded into a very delicate false ligament, on the free margin of which were several tuberculous masses.

The infection of the peritoneal surface of the diaphragm must have originated in this case from the lymphatic glands of the thorax, which receive the lymphatics of the diaphragm. The capsule of the liver was infected by contiguity for the parenchyma and the portal glands were normal. The mesenteric glands likewise were free from disease, hence the intestinal origin of the infection must be excluded. The tubercle bacilli could not have traveled through the diaphragm from the pleural side, for there was no disease of the pleura. There seems to be no other explanation than that the tubercle bacilli were forced back from the greatly enlarged, tuberculous, lymphatic glands of the posterior mediastinum into the lymph channels, which have their roots in the diaphragm. The possibility of such a retrograde movement of tubercle bacilli or cells containing them is made evident when we bear in mind the peculiar conditions. The bronchial and mediastinal glands were very large, one alone as large as a child's head. The filling up of much of the available thoracic space by these glands must have led during paroxysms of coughing to a considerable positive pressure within the cavity of the thorax, by which lymph may have been forced back into the peritoneal cavity. This mode of distribution of the tubercular virus may perhaps be not so rare as would appear at first thought, and it may be that a careful examination of a large number of animals in which the disease is still more or less restricted to the thorax will demonstrate occasional infection of the serous membranes in this way.

These observations, added to those of Rieck, go far toward proving that what has been called pearly disease in cattle is nothing more than a manifestation of a more or less advanced stage of tuberculosis of certain organs, especially the lymph glands, from whence it has overflowed, as it were, through the lymphatic system. This condition may be brought about, at least in part, by a marked resistance of certain organs of the bovine organism to tuberculosis. The lymphatic system offering least resistance becomes the seat of a chronic, prolonged disease process, in which the serous membranes, after a time, take part. This marked localization of the process is well exemplified in No. 338.

Besides the lungs no other organ was attacked by visible tuberculous changes. The disease was restricted to the lymphatic system, including the large serous cavities and, lastly, Peyer's patches of the small intestine.

We may then summarize the ways in which tuberculosis of the serous membranes takes place as follows: (1) By escape of bacilli from some focus of disease situated under one of the serous coverings, such as lungs, liver, intestines, and associated lymph glands. If many bacilli enter a serous cavity an extensive eruption of tubercles is likely to appear in the peritoneum, chiefly on the omentum; in the thorax, mainly on the dependent portion of the lungs. (2) By an accidental temporary reversion of the lymph current by which bacilli may be carried backward from the diseased gland. (3) The disease may travel from pleura to peritoneum and from peritoneum to pleura by a simple growth of the tubercles through the diaphragm (Weigert).

Tuberculosis of the serous membranes seems to cause least damage to the animals affected, if we are to judge from occasional autopsies, in which an enormous number of tubercles on these membranes may be compatible with a very fair condition of the animal, provided organs like lungs and liver are not seriously involved at the same time. There is, of course, more or less encroachment of space and perhaps considerable impediment to the normal gliding of organs on neighboring structures. A case of this kind is found on Table II (No. 590). On opening the abdominal and thoracic cavities an exceedingly extensive eruption of tubercles was found on peritoneum, pleura, pericardium, and epicardium. The impression conveyed by this appearance was of extensive organic disease. This was not the case, however. In the head the submaxillary and retropharyngeal glands were badly diseased, but in the thorax the lungs were free, in spite of the pleural affection, and the disease was restricted to the large mediastinal gland. In the abdomen the peritoneal disease had invaded the uterus. The mesenteric and lymphatic glands were affected and the serous covering of the liver was studded with tubercles, but there was no disease of the parenchyma of the liver, spleen, or kidneys. In this case the pearly disease may have started from a tuberculous mesenteric gland.

It does not appear probable, from observations made at autopsies, that organs are invaded to any extent by tuberculosis starting on their serous covering. There is, however, one important exception. Tuberculosis of the Fallopian tubes and of the uterus appears to be largely an extension of the disease by contiguity from the peritoneal covering of these and adjacent organs.

DISSEMINATION OF TUBERCLE BACILLI IN THE LYMPH CHANNELS.

The spreading of tuberculous lesions from one gland to another in the direction of the lymph stream is frequently observed. The progress,

however, seems to be so slow that this mode is frequently overtaken by others and the animal succumbs before much progress is made.

Successive infection of the glands of the head and neck is now and then noticed. In No. 611 (Table II) all the glands of only one side of the head (left parotid, submaxillary, retropharyngeal, and post maxillary) were diseased, those of the other side healthy. In another case not tabulated the infection could be traced from the glands of the head to those at the root of the neck. In No. 292 (Table V) the right retropharyngeal and post maxillary glands and the right tonsil were diseased, the corresponding structures on the left side normal.

In tuberculosis of the mesenteric glands the bacilli may, as has been stated, become diffused over the peritoneum or, what is more probable, carried into the thoracic duct.

In tuberculosis of the liver the tubercle bacilli are usually carried into the portal lymph glands at the hilus. They may also be carried through the lymph channels, which are said to pass from the liver into the thoracic cavity. Here they would probably be deposited in the large caudal mediastinal gland. This mode of infection of the mediastinal gland is probably extremely rare. For in incipient cases the mediastinal glands are in many cases diseased and the liver free. On the other hand, the liver may be extensively diseased, but the mediastinals free (No. 333, p. 43).

While tubercle bacilli appear to be usually carried in lymph channels with the current, one case of evidently retrograde movement of the tubercle bacilli has been noticed and already referred to on page 111.

DISSEMINATION OF TUBERCLE BACILLI THROUGH THE BLOOD (GENERALIZED INFECTION).

The virus of tuberculosis does not vegetate in the blood. Its presence in this fluid is accidental, due to the rupture of a caseous focus into some blood vessel, or into lymph channels (right and left thoracic ducts) emptying directly into the blood stream. The disease is therefore, as a rule, pretty generally distributed by repeated primary infection, by the lymphatic system and by auto-infection before indications of blood infection are manifest. Even after tubercle bacilli have entered the circulation they are speedily fixed in the parenchyma of the various organs, so that unless there is a continual discharge of tubercle bacilli into the blood from some focus of disease the blood infection is very temporary.

Infection of the blood may occur repeatedly in the more advanced stages of tuberculosis. Comparative pathologists have for convenience adopted two designations for two somewhat different forms of the generalized disease. When the blood has been infected with only a small number of tubercle bacilli, foci may be found scattered through the body, but only in small numbers. This condition has been denomi-

nated by Ostertag as chronic generalized tuberculosis. When a large number of bacilli have escaped into the circulation and an eruption of a large number of tubercles appears in various organs, such as kidneys, spleen, and liver, the disease has been called acute, generalized tuberculosis. The chronic form with occasional tuberculous foci in the parenchyma of organs or the glands associated therewith is not uncommon; the acute form, however, at least in that stage in which numerous tubercles are visible to the unaided eyes within the spleen, liver, and kidneys, is quite rare. The chronic form is seen chiefly in old cows which have struggled with tuberculosis for many years and in which, during this long period, there has been perhaps one, perhaps more temporary entries of tubercle bacilli into the circulation. It is now and then seen in comparatively young animals.

The parenchyma of the liver, spleen, and kidneys appears to be more or less opposed to the multiplication of tubercle bacilli, for even when there has been blood infection at some time the tubercle bacilli may leave these organs where they have been deposited by the blood stream and pass by way of the lymph channels into the lymph glands belonging to such organs, where the destructive process assumes proportions soon visible to the unaided eye. Hence, in endeavoring to trace any generalized infection, the lymph glands of such organs as the kidneys should always be examined. It is this fact which led Hartenstein to regard the lymph glands as the best (and often the only) reagents for the presence of tuberculosis in cattle. That generalized infection may have occurred without being recognizable to the unaided eye is proved by case No. 233 reported in Bulletin No. 3, page 62. The milk of this animal contained tubercle bacilli shortly before death. The udder was free, but in the pubic glands a few small yellow tubercles were found. In a fresh section of liver tissue giant cells were observed, and when subsequently sections of hardened tissue were examined numerous beginning foci of disease were found, each consisting of one or two giant cells embedded in a slight zone of round cells and containing tubercle bacilli.

Generalized infection may thus be recognized by the discovery of foci of disease in organs not accessible to the virus in any other way than through the circulation, or in the lymph glands of such organs. Tuberculosis of the subcutaneous lymph glands and of those situated in the muscular tissue of the trunk and limbs is universally accepted as indicative of the generalized disease. Such glands may be infected from without, but infection through wounds of the skin is probably quite rare.

The terms blood infection and generalized infection are not directly synonymous and require further definition. When tubercle bacilli enter the portal circulation from the digestive tract, they are carried into the liver where they may all be filtered out and fixed. Should they pass into the hepatic circulation they may reach the right side of the heart

and thence be distributed through the lungs. In order that they may gain the general or systemic circulation they must pass through the capillaries of the lungs to reach the left side of the heart. Hence we may have a local infection of the portal circulation, as well as of the pulmonary circulation without infection of the blood going to the whole body. When tubercle bacilli enter the thoracic duct from diseased glands of the abdomen or thorax, they enter the venous system and therefore they must first run the gauntlet of the capillary system of the lungs before they may enter the general circulation. The condition most favorable to infection of the entire body is tuberculosis of the lungs with discharge of tubercle bacilli into any branch of the pulmonary vein. They will then pass directly to the left side of the heart to be distributed over the entire body. Should tuberculous foci break into arteries the conditions would be somewhat different and their consequences easily traced. Their denser coat probably prevents this accident from occurring.*

Generalized infection has been quite frequently observed at German abattoirs. Referring to our own cases in Tables I, II, and III, and excluding those on Tables IV and V as being mainly selected for their suspicious or bad condition, we have among the first lot of 108 animals 3 cases of generalized infection.† If we take those advanced cases given in Tables IV and V, exclusive of D and No. 237, not known to be tuberculous when killed, we have out of 12 cases 4 with generalized disease. This bears out the general assumption that, with rare exceptions, generalized disease appears late in the course of the disease.

Generalized infection, both chronic and acute, has received considerable attention, especially by German authorities, because of its important bearing on the infectiousness of meat and milk. Infection of the bony and muscular tissue, and more particularly the lymph glands embedded in them, is regarded as of sufficient gravity by the German meat-inspection authorities to forbid the utilization of the meat of such animals, excepting after it has been cooked under the direction of these authorities. Since tuberculosis of the bones and muscular tissue, or of the glands embedded in them, is possible only after the virus of tuberculosis has been transmitted in the blood, generalized infection manifesting itself in any part of the body throws suspicion on the meat.

* The immunity, as it were, of at least the larger arteries, owing to the denser structure of their walls, is very well shown in contagious bovine pleuropneumonia. In this disease the coats of the pulmonary veins embedded in the diseased region are frequently penetrated by cell infiltration from the surrounding connective tissue. This leads to inflammation of the intima and thrombosis. In the arteries, on the other hand, thrombi are not found.

† The diagnosis in one of these cases (No. 303, page 32) is based on the presence of old tuberculous deposits in the udder (pubic) lymph glands. Inasmuch as the infection may have come from without through the udder (although this the writer is not inclined to believe), blood infection in this case is somewhat doubtful.

Generalized infection is furthermore of great importance in its bearing on the infection of milk. The possibility of udder infection from without being conceded, we nevertheless find that most of the udder tuberculosis encountered is a result of blood infection. The tubercle bacilli are carried from some internal focus by way of the blood into the udder. Hence, in all cases of generalized disease, the milk should be regarded as dangerous. The difficulty from the practical standpoint lies in the recognition of such generalized infection during life. With the meat the question is simple enough and resolves itself into the thorough inspection of every carcass at the abattoir by a trained inspector. With the living animal we have only a few guides, such as the condition of the udder (pubic) lymph glands or the enlargement of some of the superficial lymph glands, such as those of the shoulder and flank. But even these guides are untrustworthy and liable to lead to erroneous inference at any time. This question of the relation of tuberculosis to the public health is too broad a one to be discussed here and it has been referred to simply to call attention to the important practical bearing of blood infection in tuberculosis.

INFECTION OF ANIMALS BY THEIR OWN TUBERCULOUS DISCHARGES (AUTO-INFECTION).

Cattle may become reinfected by their own tuberculous discharges and thereby materially hasten the dissemination of the disease in their own bodies. Perhaps the most common process of reinfection is the swallowing of tubercle bacilli which have been coughed up from some disintegrating focus in the lung tissue. Tubercle bacilli coughed up in this way frequently produce more or less extensive tuberculosis of the bronchial tubes, the trachea, and the larynx. It has already been stated that tuberculous lesions of these structures have not been observed excepting where the lung tissue itself is involved and the disintegrated tissue is breaking into an air tube. The inference that infection of the air tubes is secondary to the lung lesion, is, therefore, justifiable. The tubercle bacilli coughed up may further infect the tonsils and lymph glands of the head and neck. When they are swallowed tuberculosis of the digestive tract and the liver may follow as with primary infection from without and simulate an infection of the food.

To what extent such auto-infection actually takes place it is impossible to estimate, for any infection which has produced lesions within the reach of the digestive tract may have come from without as well as from the lungs. It is probably of little significance when the discharged material from the lungs is slight in amount. When it becomes very abundant there may be extensive secondary disease of the intestines, as in the case of No. 338 (page 46), in which the Peyer's patches of the small intestine were completely infiltrated with tubercles.

A consideration which complicates any estimate of secondary infection is the varying susceptibility of different organs to infection with age. The writer is inclined to the view that the region of the throat and that of the small intestine are more likely to absorb tubercle bacilli early in life than later on, while the lungs seem to become with age the preferred seat of the disease. The demonstration of this assumption is complicated by the fact that calves are more exposed to food infection than adult animals, because of the dangers of tubercle bacilli in the milk. One point in favor of the increased immunity of the digestive tract later in life is indicated by the absence of lesions in those animals in which there is manifestly a discharge of tubercle bacilli from the lungs. This is borne out by the cases included in Table I, in which throat infection and lung infection are usually not associated together. The whole subject is a difficult one and not of sufficient economic importance at the present time to deserve much attention on our part. Of more importance is the possible infection of the udder, through the teats, from discharges of the same animal, especially the vaginal discharges when tuberculosis of the uterus is present.

HEREDITY AND TUBERCULOSIS.

The transmission of the bacillus of tuberculosis from the parents to the offspring before birth must be clearly distinguished from the transmission of certain bodily conditions which favor the multiplication of tubercle bacilli after infection.

The slow insidious progress of this disease in the infected body, its apparent disappearance and subsequent reappearance after variable periods of time, together with the somewhat peculiar modes of dissemination of the bacilli within the body have made the investigation of this subject unusually difficult. There are some pathologists who claim that much of this disease is contracted before birth. The majority of authorities are, however, inclined to the view that only very few cases are the result of transmission before birth and that infection after birth is the rule.

This subject is of special importance to us, for it is highly desirable to know to what extent animals are born with the disease and under what circumstances the transmission of the virus before birth is likely to take place. A tuberculous calf is more dangerous than a tuberculous cow, because it may carry foci of disease in the udder even before this organ begins to secrete.

The tubercle bacillus may be conceived of as passing from parent to offspring in several ways:

- (1) It may pass in the semen of the male and infect the ovum directly.
- (2) The ovum may be infected by disease of surrounding structures (peritoneum, ovaries, Fallopian tubes) in the female.

(3) The fetus may be infected by the passage of tubercle bacilli from the maternal placenta into the fetal circulation.

As regards the two first-mentioned ways little need be said. As shown by A. Gärtner,* the possibility of a direct transmission of tubercle bacilli from father to offspring is so slight that it need hardly be taken into consideration. On the other hand, it has been shown by Gärtner that tubercle bacilli may pass from the mother into the ovum, but this mode of infection must likewise be regarded as very rare.

The infection through the placenta is probably the most frequent cause of congenital tuberculosis. It may take place when, in consequence of generalized tuberculosis of the mother, tubercle bacilli are in the circulation and become lodged in the placenta, whence, through some ruptured vessel, they may pass into the blood of the fetus. The same is perhaps even more likely to occur when the uterus has become the seat of tuberculous changes either secondarily or primarily through infection. To what extent tuberculosis of this organ must have progressed before conception ceases or the fruit fails to mature seems not to be known.

It may be considered as definitely settled by experiment and observation that the bacilli may pass from the mother to the fetus under certain conditions. The differences of opinion refer merely to the relative frequency of its occurrence. Baumgarten claims that with most cases of tuberculosis among human beings the disease begins before birth and is thus "inherited." Gärtner,† after thoroughly sifting the whole subject and enriching it with experiments of his own, comes to the conclusion that in the human subject the tubercle bacillus frequently passes from the mother to the fetus. He does not, however, take the extreme position held by Baumgarten.

It remains for us to consider how frequently calves are born with tuberculosis. Only a small number of cases of congenital tuberculosis have been reported. Of these a few deserve mention.

In 1885 Johnne‡ found tuberculous lesions in the liver, portal glands, lungs, and bronchial glands of a fetus 8 months old. The mother had been examined at the abattoir and found affected with advanced pulmonary tuberculosis.

Malvoz and Brouwier§ have reported two cases of congenital tuberculosis. In both the glands at the hilus of the liver, the liver tissue itself, and the glands at the hilus of the lungs contained tuberculous foci. The lungs themselves were intact.

Bang|| found, in the course of extensive inquiries and personal obser-

* Ueber die Erbllichkeit der Tuberculose. *Zeitschrift für Hygiene*, XIII (1893), p. 101-251.

† *Loc. cit.*

‡ Fortschritte der Medizin, 1885 p. 198.

§ *Annal. de l'Institut Pasteur*, 1889, p. 189.

|| *Deutsche Zeitschrift f. Thermedizin*, XVI (1890), p. 409.

vations in Denmark, that congenital tuberculosis was not such a rare occurrence after all. He presents three cases examined by himself. In the first case, a calf born dead, the glands at the hilus of the liver contained cheesy-calcareous foci. In the second case, a calf presumably 2 days old, the liver, the bronchial, mediastinal, lumbar, and perhaps other lymph glands contained cheesy-calcareous deposits. A few were found in the lung tissue. In the third case, a calf about 14 days old, the liver, with portal glands, the lungs, with bronchial and mediastinal glands, and one kidney contained tuberculous lesions.

Lungwitz* found in a fetus about 6 months old tuberculous lesions in the lungs, liver, bronchial, mediastinal, mesenteric, and retroperitoneal lymph glands. The dam, about 10 years old, was affected with generalized tuberculosis, including tuberculosis of the uterus and placenta.

In a second case the dam, but 2 years old, was affected in the same way as the first mentioned. The fetus, about 4½ months old, was affected with generalized tuberculosis. Lesions were found in the liver, spleen, kidneys, lungs, and corresponding lymph glands. The author adds that in the Leipsic abattoir, where these cases were encountered, he and Rieck had examined in all about 200 fetuses, which came from diseased cows. The two cases reported were the only ones found. We have thus but 1 per cent of transmitted disease in case of 200 pregnant animals which failed to pass the inspection owing to advanced generalized disease.

Quite recently Bärlund† found two cases of congenital disease. Both calves were about a week old when killed. Calcified as well as fresh tubercles were found in the lungs and lymph glands of thorax.

The occurrence of infection before birth is thus positively established by these cases; but have we any reason to believe that much of the disease of later years is due to the transmission of tubercle bacilli in the uterus?

The answer to this question must be based mainly on pathological data-obtainable by the thorough post-mortem examination of a large series of cases. Animals in which the disease is already well advanced are of but little service in the study of this question, since it is impossible to trace definitely the place in the body where the bacilli first began to multiply. The tuberculin tests furnish a considerable number of cases in which the disease is in its earlier stages and still restricted to one or more primary foci. To these we must look for aid in the solution of this problem.

If we examine such cases carefully we shall find that usually the lymph glands of the throat, the lungs, or the intestines are diseased. These glands have been described in detail and their mode of infection pointed out in a previous chapter. This consists in brief in the passage

* Archiv. f. wiss. u. prakt. Thierheilkunde, xx (1894), p. 204.

† Centralblatt f. Bakteriologie, xv (1894), p. 498.

of one or more tubercle bacilli through certain tissues and their lodgment and multiplication in the lymph glands into which the lymph of such tissues drains. This peculiar settling down of tubercle bacilli in case of so many infected animals in the glands which receive lymph from organs or membranes in direct contact with the outer world (food and air) is very good evidence that the tubercle bacilli are carried from without inward. If they had been deposited in these glands by means of the blood during the fetal period, the question arises why not in other glands which after generalized infection appear equally susceptible to disease?

In a large number of cases of incipient disease the mediastinal or the bronchial glands which receive lymph from the lungs are the only diseased organs. Why should the virus localize in these glands by preference unless they are the first places of deposit from the air drawn into the lungs.

There is every reason to believe that most of the tuberculosis of cattle is not transmitted at or before birth, but is contracted later on in life by contagion. Baumgarten, on the other hand, explains the isolated disease of the lymph glands as inherited, because tubercle bacilli, according to his views, can not enter the body without leaving some disease at the point of entry. This phase of the subject has already received some attention on page 108. We can not at present accept Baumgarten's theory, and believe that tubercle bacilli, may pass through the lungs, for instance, by way of the lymphatics into the lymph glands without causing visible disease of the lungs themselves. Bang,* on the other hand, is inclined to accept Baumgarten's view and to regard disease of the mediastinal glands as a result of congenital disease.

Not only does the location of the disease as stated above militate against this view, but the occurrence of gland tuberculosis three or more years after birth is quite common. Baumgarten would explain this as a kind of latency of the virus, but in many cases the disease in full-grown animals is still quite fresh. The writer recalls the case of a cow 7 years old in which the lesion was limited to one of the thoracic glands in the youngest stage recognizable. The tubercles were distinct as minute granulations, and under the microscope no necrosis could be detected.

If all the cases of tuberculosis of lymph glands were to be accounted for as the result of intrauterine infection nearly all bovine tuberculosis must be regarded as congenital.

Since the probability of an intrauterine infection of the posterior mediastinal glands is much greater than that of the throat or mesenteric glands, it is worth while to examine for a moment the ways in which the pulmonary glands may become infected from this direction. It is conceivable that tubercle bacilli may become lodged during intrauterine life in the mediastinal glands by taking the following courses:

* Deutsche Zeitschrift f. Tiermedizin, XVI (1890), p. 409.

(1) They may pass from the placenta directly into the right side of the heart through the ductus venosus and thence to the lungs. Here they may become filtered out of the blood and carried in the lymph channels into the mediastinal glands.

(2) They may pass through the liver first, thence through the heart, and then follow the course indicated under 1.

(3) They may pass into the liver, there become filtered out into the lymph channels, in which they may be carried through the diaphragm into the thoracic glands.

(4) They may be filtered out of the blood which passes through the mediastinal glands.

Of these channels the last is hardly to be thought of when we bear in mind what a minute percentage of the total blood passes through the mediastinal glands at any given moment. Why other equally susceptible glands should not become affected at the same time seems inconceivable. The third channel is so complicated that if it were actually followed we should also expect to find tuberculosis of the liver and the portal glands. The first and the second seem the most direct. As only a small portion of blood does not pass through the liver, we might expect to find the liver or its glands (portal) in nearly all cases of congenital disease affected together with the pulmonary glands. In the cases cited above all but Bärhund have reported tuberculous changes in the liver or its glands. In the tuberculosis of adult life we find much tuberculosis of the mediastinal glands without corresponding disease of the liver or its glands, a fact militating against the foetal origin of the infection and in favor of inhalation as the real channel.

A further argument against the theory of congenital tuberculosis as a prominent factor is that drawn from statistics which demonstrates an increase of the number of infected animals with age. Any latency of the disease in calves is hardly acceptable, for it seems on the whole more rapidly fatal in the young than in the old.

The only fairly positive case of congenital tuberculosis which the writer has encountered is that of a Jersey calf whose history is worth recording here. The calf was born December 12, 1893. The mother was recognized as being ill three months before. Her udder was normal. After penning the calf with her and allowing it to take as much milk from the dam as it pleased for one month the dam was killed. The calf was killed when $4\frac{1}{4}$ months old. It was apparently in good health. The autopsy, however, revealed a case of extensive generalized tuberculosis.

Right knee fold gland contains a large caseous focus; left normal.

Left submaxillary gland contains a minute, entirely gritty focus, the right a large caseous-calcareous focus. The postmaxillary glands contain a few small foci.

Extensive tuberculous deposits on the costal and pulmonary pleura and on the pericardium. Great enlargement and necrosis of mediastinal and bronchial glands.

In the lung tissue a small number of recently necrosed foci one-half to three-fourths inch in diameter.

if tuberculosis should be allowed to increase uncontrolled in the future as in the past congenital tuberculosis will increase in frequency and thus at the very beginning of life lay the foundations for a disease which under this form will render the affected animal a great menace to public health as well as a dead loss to agriculture.

Much has been said and written concerning the inheritance of a certain combination of bodily characters which increase the chances of the subject to contract the disease when exposed to it or which tend to a more rapid course of the disease after it has once gotten a foothold in the body. It is an exceedingly difficult subject to discuss, because we know little or nothing definite about it. Theoretically there seems to be no reason why some animals or breeds should not be more susceptible than others, but the conditions under which observations can be made to prove or disprove this theory are complex and likely to bring out erroneous conclusions. The element of contagion is such a prominent factor at all times that individual or racial susceptibility can not be studied satisfactorily until it can be successfully controlled. Inherited susceptibility is also not separable from acquired susceptibility due to depressing environment and unsuitable food.

A more satisfactory method of approaching the subject would be the experimental inoculation of individuals from different breeds, chosen as nearly alike as possible, and a careful study of the progress of the induced disease. Such experiments, though expensive both as to time and money, might throw more light on the subject of tissue immunity than prolonged observation of the disease as acquired naturally. If, however, the disease can be controlled by weeding out all tuberculous animals from a herd at certain regular intervals and thus removing the element of contagion entirely, the question of heredity of disposition will no longer be of any practical importance, for there can be no tubercles without the tubercle bacillus.

THE DIFFERENTIAL DIAGNOSIS OF TUBERCULOUS LESIONS.

In the recognition of tuberculosis at the post-mortem examination errors may be made in two directions: Certain alterations in the tissues which are tuberculous in character may be overlooked and certain changes may be pronounced tuberculous which are due to other causes.

The peculiar tissue reaction which leads to the formation of minute tubercles, their coalescence, and the subsequent caseation or calcification of the mass of new tissue formed thereby, needs not be seen frequently by a trained eye before their characteristics are firmly impressed on the mind. There is, furthermore, the constantly recurring affection of the lymph glands either with or without disease of the vital organs which belongs to no other disease of cattle.

It may, however, occur now and then that the disease process is so recent that the changes induced are too slight to be detected by

A few tubercles on omentum. The portal glands as large as hen's eggs, completely necrotic, with much embedded calcareous matter. In the liver only a few small (one-eighth to one-half inch) foci. On the capsule a few flattish excrescences. In the spleen some necrotic tubercles one-fourth inch in diameter. One flattish tubercle on capsule.

Renal glands tuberculous.

Mesenteric glands varying in size up to hen's eggs; completely necrotic, with calcareous particles.

While it is not to be denied that this calf may have contracted the disease through the milk, yet the writer is inclined to look upon the disease as contracted from the mother before birth, since the extent of the disease is hardly explainable in any other way. The writer has also seen several other cases of disease in animals not over 2 years old in which the generalized infection, with but slight lesions at any one point, suggested either congenital disease or infection very early in life. There is, to be sure, no positive proof of congenital infection in such cases, but the wide dissemination of tuberculous lesions at an early age is very suspicious when we bear in mind that tuberculosis becomes generalized only after prolonged local disease.*

Among those who have given this subject considerable attention Nocard is inclined to regard congenital disease as uncommon and safely left out of account in considering means of prevention. The writer is inclined to accept the same view from an independent study of this question. The best view to take of this subject is the one suggested by Gaertner, that congenital tuberculosis or the transmission of tubercle bacilli from the mother to the fetus is but one of the many ways in which the virus is disseminated. Circumstances at times may contribute to more, at times to less, infection of this kind. There is no doubt that

*After this article had left the writer's hands a second case of intrauterine infection, much more convincing than the one referred to in the text, was dissected. A brief description here is justifiable on account of the comparative rarity of such cases.

A cow, about 5 years old (No. 268 in Table V), was killed in an extremely emaciated state twenty-one days after giving birth to a calf. The autopsy showed very extensive, probably primary, disease of the lungs and pulmonary glands. From the lungs the coughed-up tubercle bacilli had recently invaded the retropharyngeal and the mesenteric glands. The portal system was also infected.

The pleura had become involved by contiguity with the lung disease and thence the peritoneum had become affected. Blood infection was indicated by slight disease of both kidneys.

In the left horn of the uterus an area about 2 to 3 inches square was involved. The wall was much thickened and on section aggregations of tubercles were found in the submucous tissue, some with necrotic centers. About six of the cotyledons were involved.

The calf killed at the same time (21 days old) showed unequivocal marks of congenital tuberculosis. The lesions were limited to the liver and its glands, one kidney and its gland, and two posterior mediastinal glands. The tuberculous masses were in all cases necrotic and calcareous centrally.

It seems that the disease of the uterus in the mother was older than three weeks. The calf was probably infected from this focus before birth.

They may be readily seen by the naked eye, but their relative abundance is more easily determined by passing the intestine either slit open or still uncut through the hands. The intestinal wall then feels as if beset with shot-like bodies. When the tube is slit open, the mucous membrane appears elevated by small hemispherical tumors varying in size from barely visible nodules to bodies as large as peas or even larger. These tumors are, as a rule, isolated. Rarely several are close together. Only in very extensive infection of sheep are they frequently so abundant as to form by their aggregations large elevated patches or beds. They are not all of the same size in the same animal, but vary as stated. If we examine these projections more closely we shall find that in all but the smallest ones the center appears opaque and yellowish. This yellow nucleus is more or less irregular in outline. The mucous membrane covering them is unharmed except as to the presence of a little depression on the summit of the nodule, which is probably the point of exit of the once encysted worm. This opening may be in the center of a bluish spot, probably the débris of a hemorrhage, caused by the outward-moving worm. In the larger nodules a slight pressure forces from this minute opening some of the softened contents of the cyst.

The situation of the nodules is in the submucous tissue. The mucous membrane may be scraped away and leave the nodule intact. When a small one is teased out of its surroundings and crushed between two slides the parasitic worm, about 1 mm. ($\frac{1}{25}$ inch) long and almost invisible to the unaided eye, may be detected in some cases. The larger the nodule is the less likely the search for the worm will be successful.

The larger tumors, usually about one-fourth inch in diameter, consist of a thin, smooth capsule containing putty-like substance of a yellowish or greenish-yellow color, easily removed. In very old tumors the thin capsule may inclose a calcified mass of very irregular surface.

In some cases most of these intestinal tumors have a decided bluish color. This is probably due to some former hemorrhage, as suggested above.

These tumors may be distinguished from true tubercles in a variety of ways. In the first place, tuberculosis of the mucous membrane of the intestines is quite rare. The writer has seen but one case in 150 tuberculous animals. In this the Peyer's patches were involved.* Infection by way of the intestines shows itself mainly in the mesenteric glands. Any affection of the mucous membrane without disease of these glands must be looked upon with suspicion. This worm affection is, furthermore, very common in certain regions, and usually affects all animals alike.

The character of the worm tubercle is quite different from that of the true tubercle. Setting aside the recognition of the worm, which is possible only in young tumors, we have sufficient points of difference to make a diagnosis with the naked eye possible in most if not in all

* See autopsy notes of No. 338, p. 46.

naked eye. The earliest visible manifestations in the lymph gland are seen on the cut surface as whitish patches, having, when viewed in a good light, a slightly granular appearance. Simple hyperplasia of the lymph glands in which the follicles appear on the cut surface as smooth, whitish, slightly elevated, round patches must be carefully distinguished from early tuberculous lesions. This hyperplasia is simply an increase in the number of lymph cells composing the follicle, and is especially conspicuous in young animals. In these the glands lack the pigment markings which appear later on in life, and the uniformly whitish appearance of the cut surface may erroneously suggest tuberculosis. It is not to be denied that the beginnings of tuberculosis may now and then lurk in these follicles, but after somewhat extensive examination of sections of such regions and a uniformly negative outcome, the writer is inclined to believe that they may safely be passed over.

Mistakes are more likely to occur by confusing lesions due to other bacteria, to parasites, and to traumatism with those of tuberculosis unless a certain amount of caution and reserve is exercised and the aid of the microscope or of those especially trained is invoked.

Bacterial lesions, which resemble tubercles closely and which go to make up the pathological condition known as pseudo-tuberculosis, have been found among sheep and smaller animals, but not among cattle. A general review of this subject will be found in Bulletin No. 6 of the Bureau of Animal Industry (pp. 87-95), to which the reader is referred.

Forms of broncho-pneumonia may now and then simulate tuberculosis of the lungs, but the characteristic distribution, as described on page 91, will generally assist in making a prompt diagnosis. One of these forms of pneumonia has been described by Kitt* who found in sections of the lung tissue masses of a specific bacillus. The various cases of broncho-pneumonia examined by the writer were so readily distinguishable from tuberculosis that any remarks would be superfluous. Among the more common as well as more perplexing lesions frequently found in cattle, those due to entozoa stand first and deserve a more detailed description.

WORM NODULES IN THE SMALL INTESTINE.

These have been looked upon as the result of true tuberculosis in several cases which have come to the writer's notice. They are very common in the region about Washington. The writer has also seen them in New York. In tissues from cattle slaughtered at Chicago they were likewise recognized. It is highly probable that they are widely disseminated in our country.†

* Eine bacilläre Pneumonie beim Rinde. Monatshefte für praktische Tierheilkunde, 1 (1890), p. 115.

† They have been noticed by Dr. Arango in Colombian (South American) cattle.—The Veterinary Journal, 1894, p. 105.

The contents are therefore not removable in toto, except after complete softening and circumscription of the tuberculous process. The cheesy mass is, moreover, mainly fatty and granular debris. With true tuberculosis an extension of the process is usually noticeable; with worm tubercles this is not the case, the capsule is directly contiguous with healthy gland tissue, and all evidence of encroaching infiltration is absent.

Isolated tubercle-like lesions are found occasionally under the cortex of the liver, which are probably of parasitic origin. Unless tuberculosis has been plainly recognized in the glands at the hilus or elsewhere in the body, the diagnosis should be left open until such nodules have been examined under the microscope.

Yellow patches, due to fatty degeneration, may appear on the margin of the liver, probable as a result of embolism. Though they resemble more or less closely the necrotic patches of the tuberculous liver in guinea pigs, they contain no traces of the tuberculous process. In general tuberculous foci in the liver of cattle are roundish and provided with a thick, dense, connective tissue wall.

The importance of a correct diagnosis of tuberculosis of the udder makes it imperative that mistakes be avoided in determining the nature of any abnormal appearances on post-mortem examination. It is essential that statistics of udder tuberculosis be accurate, for it is upon them that the future action of sanitarians will be largely based in dealing with this disease. It is highly probable that udder tuberculosis whenever encountered will be generally recognized as such. It is equally probable that other changes may now and then be called tuberculosis. In this connection attention should be called to the aberrant appearances occasionally presented by the freshly-cut surface of udder tissue. The usual pinkish surface is, in some cases, variegated by patches of yellow representing foci of intense fatty changes. In portions which have lost the power to secrete the increase of connective tissue compresses the lobules and gives the cut surface a granular appearance which might be mistaken for tubercular infiltration. Very deceptive are certain yellow nodules which project above the cut surface. They are lobules distended with fat and have the normally soft consistency of udder tissue. In any case of suspected udder tuberculosis the tubercle bacilli should be demonstrated, or else the histological structure of tubercle determined in sections of hardened tissue.

Another set of deceptive lesions frequently encountered at autopsies of cattle are those due to the action of foreign bodies swallowed with the food. The frequency with which this is observed and the extensive, often fatal, injuries which are induced thereby, ought to impress cattle-owners with the necessity of carefully protecting their herds from such calamities.

The lesions due to foreign bodies are usually situated on the second stomach (reticulum) in the form of enlargements or tumors, varying in

size up to an orange. The smaller ones have an almost cartilaginous hardness, and when incised a small amount of creamy pus is found in the center. In the larger ones the capsule is equally dense but not so thick relatively. They also contain the homogeneous creamy pus, which usually has a penetrating but not offensive odor.

These abscesses are associated with more or less increase in the connective tissue and the binding down of the ventral or narrower end of the liver to the diaphragm. This condition is so common that the writer has seen very few older cows without attachments of the liver to the stomach. The situation of the abscesses described, their consistency and contents are sufficiently characteristic to prevent any errors of diagnosis, if attention has been once called to them.

Foreign bodies not infrequently work their way into the thoracic cavity where they may produce abscesses in the lung tissue. These are readily distinguishable from softened tuberculous foci by their relation to adhesions of the lungs to the diaphragm and subphrenic lesions. Such abscesses are also associated with hyperplasia of the interlobular tissue of the surrounding lung tissue and firm red hepatization of the latter. Cavities due to tuberculosis are as a rule surrounded by a zone of easily recognizable fresher tubercle eruptions, which at once place the nature of the cavity beyond doubt.

SOME PRACTICAL SUGGESTIONS FOR THE SUPPRESSION AND PREVENTION OF TUBERCULOSIS.

By THEOBALD SMITH.

In endeavoring to seek appropriate means for the suppression of this disease, we find ourselves confronted with conditions quite different from those obtaining for most other infectious diseases. These conditions are in brief as follows:

- (1) The present wide dissemination of the disease, no territory being absolutely free from it.
- (2) The large percentage of infected cattle which are in the earliest stages of the disease, or in which the lesions are insignificant, stationary, or healed.
- (3) The absence of disturbances of health for considerable periods of time after infection.
- (4) The possible transmission of tubercle bacilli from cattle to man, more particularly in the milk.

Nearly all of these peculiarities have their source in the slowly and insidiously progressive nature of the affection which prolongs the duration of the disease from days to months and years. It is this character which makes the complete eradication of bovine tuberculosis a work of huge proportions, involving serious financial sacrifices.

In the following pages the subject of prevention is dealt with as it may be applied by the individual stock-owner, since this disease, more than any other, needs the combined efforts of individuals for its restriction. It makes the greatest havoc in the herd in which it exists, and rarely travels to other herds, excepting in the diseased animal which is purchased or exchanged. It is, in fact, possible for each herd-owner to protect himself quite successfully from outside infection, as is shown in the following pages which treat of the contagiousness of the disease, the removal of affected cattle, and some general sanitary measures.

THE CONTAGIOUSNESS OF THE DISEASE

Is linked to the tubercle bacillus. Without it, tuberculosis can not develop. Hence, our knowledge of the transmission of the disease is derived largely from what we know of the life history of the tubercle bacillus within and without the animal body.

with the udder or the uterus,* should be looked upon with grave suspicion and their milk excluded at once from sale. If these extenuating circumstances be borne in mind by the public health officials much hardship may be now and then avoided and the work of extermination of the disease be carried on more smoothly and more effectually in the end.

Another phase of this question which should not be overlooked is the relative danger of the air of cow stables to human beings. If more than three-fourths of all tuberculous cattle have been infected through the air of cow stables why is not the air of stables equally dangerous to human beings frequenting them? It would certainly be of interest for public health officers to look into this matter more closely.

TABLES SHOWING THE DISTRIBUTION OF TUBERCULOUS LESIONS IN THE BODY OF INFECTED CATTLE.

In the following pages an attempt has been made to tabulate the lesions as found in tuberculous cattle during the past two years, in order that the reader may see at a glance the extent of the lesions, their location, and the probable manner of infection.

The preponderance of air over food infection in the Washington herd is well shown in Table I. In Table II the conditions are different. Food infection played a prominent part in this herd, as shown by the frequency with which the throat and mesenteric glands were found diseased.

In Table III air infection again predominates. In Tables IV and V mainly advanced cases are given in which the primary foci of infection are not definitely traceable.

The amount of disease in any given organ is indicated roughly by the number of crosses, a single cross indicating slight infection. Disease of the retropharyngeal glands is not indicated in this way, a single cross being used to indicate disease of the right or the left side. Generalized or blood infection is indicated in the three last columns; pearly disease in the columns headed peritoneum and pleura.

It should be noticed that in this list of 126 head of diseased cattle, among which there were not less than 100 milk cows, one case with tuberculous udder and three others with infected udder glands were found.

*Vaginal discharges may contaminate the milk with other pathogenic bacteria unless extreme cleanliness is observed.

bull to other cows. A diagnosis may be made by the examination of the discharge for tubercle bacilli.

The foregoing statements apply to individual herds only. To what extent does the danger extend beyond the diseased herd to others in the neighborhood? To this we may give the general answer that there is no danger unless the animals mingle on the pasture or in the stable. Tubercle bacilli are not carried in the open air, or if they are, their numbers are so small that the danger of infection is practically absent.

It is also highly doubtful whether they are ever carried in sufficient numbers by third parties from place to place to become in any sense a danger. The reasons for this must be sought for in the tubercle bacillus itself. The diseased cow is the only manufacturer of tubercle bacilli* as well as the chief disseminator. Tubercle bacilli after having left the body of the cow (and usually in small number) do not increase in numbers in nature but suffer a steady decrease and final extermination in four to six months at the longest. Only after they have entered the bodies of susceptible animals do they again begin to multiply. Hence with this disease the only danger to other herds lies in direct contact, or in the transfer of a diseased animal or of milk from such an animal. The greatest danger exists in the immediate surroundings of the infected and loses itself as the distance increases.

REMOVAL OF DISEASED ANIMALS.

In order that any infectious disease may be effectually controlled it becomes of the utmost importance to recognize in the living animal not only advanced stages but even the slightest infection. This essential requirement seems to have been found in tuberculin. In the first article of this bulletin (pp. 7 to 74) the reader will find a detailed statement of its uses. The writer wishes to add here only a few remarks from a pathological point of view. Extensive use of tuberculin in Europe and in this country has shown that in a certain percentage of healthy animals a high reaction may follow the injection of tuberculin. On the other hand a small percentage of animals which fail to react show tuberculous lesions at the autopsy. How are we to interpret these inconsistencies?

Nocard, a prominent French authority,[†] is moved to state that an elevation of temperature of 2 or more degrees Fahrenheit after the injection of tuberculin invariably means infection, and that if lesions are not found at the autopsy this has been badly performed. Most German authorities are not inclined to accept the infallibility of tuberculin. The writer sides with the latter, for he has failed to detect disease after hours of searching in some cases. In several others which

* Other domestic animals may now and then be tuberculous, but this danger is hardly worth considering at present.

† *Congrès pour l'étude de la tuberculose chez l'homme et chez les animaux*, 1890, p. 22.

gave no reaction the lesions, though slight, were as marked as in others in which a high fever reaction had been obtained.*

It is not to be denied that in the one class of cases the lesions may be so slight, the changes so recent, that they escape attention, and that in the other class the lesions, which are usually quite restricted, are undergoing a healing process. However, we have not yet reached that stage of information which will permit us to explain satisfactorily these discrepancies, and hence we can not as yet unqualifiedly accept the infallible action of tuberculin, and we must content ourselves with the statement that it is a diagnostic agent of very high power.

Accepting the great value of tuberculin in revealing tuberculosis not recognizable by any other means during the life of the animal we are confronted by the necessity of segregating those animals which have reacted with a high temperature and either curing or slaughtering them.

The cure of tuberculosis with tuberculin has been attempted by a small number of observers. Frequent injections of small doses into guinea pigs were made by Pfuhl† and by Kitasato‡ with the result that while the disease was greatly prolonged in some animals a cure was not attained. Others have attempted to heal experimental tuberculosis of the eye in rabbits. The most prolonged observations made by Trudeau§ in this country have shown that while a cure may be apparently brought about a relapse is likely to occur at any time. With cattle the case is somewhat different. If tuberculin could be made to point out those numerous cases in which the disease is restricted to one or more small foci in the lymph glands a course of treatment with injections of tuberculin might be successful in stimulating the body to a speedy healing of these foci. But in selecting tuberculous animals with tuberculin it is quite impossible to discover how much disease is present. To treat any but the most incipient cases would be worse than useless. The same objection would hold for any other remedy likely to be introduced. The treatment of this disease is not to be recommended, therefore, and other means of disposal must be sought.

Nocard,|| in view of the fact that many animals which give a marked tuberculin reaction have only insignificant lesions in the body, recommends that all such as give a distinct reaction be rigorously quarantined from the rest of the herd. The healthy animals should be placed in thoroughly disinfected stables and new animals admitted only after they have successfully passed the tuberculin test. He further recommends the prompt fattening for slaughter of the infected animals which are in good condition. The lesions will be so slight, he adds, that no

* See Nos. 319, 322, 334, 360, pp. 39 to 56, and D, Table IV.

† Zeitschrift f. Hygiene, XI, p. 241.

‡ Zeitschrift f. Hygiene, XII, p. 321.

§ Trans. of the Association of Amer. Physicians, 1893, 1894.

|| Loc. cit.

inspector dare demand the seizure of the meat at the abattoirs. During the fattening they may be used as before the test. The preventive measures recommended by him thus comprise the tuberculin test with segregation of the infected animals. These must not be used for breeding nor must they be sold, exchanged, or given away. The owner can only give them up to the butcher.

If we accept Nocard's view of the infallible action of tuberculin his suggestions require no amendment. We are not inclined to accept it at present, however. Hence it is essential that the tuberculin test be repeated not later than after an interval of six months, so that it may reveal any cases not detected at the first test. Future repetitions are equally important, as the disease germs may possibly be introduced later on by tuberculous human beings, or by tuberculous cats, dogs, and other domesticated animals.

In the absence of the tuberculin test or of organized official inspection, the stock owner should carefully and promptly remove from his herd and have destroyed:

- (1) All animals which show emaciation with coughing and any suspicious discharges from the nose.*
- (2) Those animals with enlarged, prominent glands about the head (in front of the ears, under and behind the lower jaw), or enlarged glands in front of the shoulder, in the flank, and behind the udder.
- (3) Animals with suspected tuberculosis of uterus and udder.

GENERAL SANITARY MEASURES.

It will probably require more or less time before the use of tuberculin will have become generally established. Hence preventive measures of a general character must still be kept in view for some time to come. These measures partly suffer shipwreck from the fact that it is often difficult to recognize even advanced disease during life. Still, much can be done to reduce the amount of infection by following out certain general and specific suggestions which the renewed study of the disease has either originated or else placed on a more substantial basis.

Perhaps the most important preliminary suggestion to be made is that the owner of cattle should endeavor to familiarize himself as much as possible with the general nature of tuberculosis, its cause, the ways in which the virus may leave the body of the sick and enter that of the well, and, lastly, the ways in which it spreads within the body. He will by the acquisition of such fundamental knowledge lift himself above the plane where quackery and specifics abound, and understand pre-

* Now and then emaciation is due to other causes, such as the presence of foreign bodies in the chest, parenchymatous disease of liver and kidneys, chronic bronchopneumonia, etc. Animals affected with these diseases are of no permanent value, and their destruction is, in the end, an actual saving, since such maladies are not curable.

TABLE III.—*Distribution of tuberculous lesions in portions of herds III and IV (New York).*

Case.	Age.	Retro-pharyngeal glands.	Infection probably through the food.				Perito-neum.	Uterus.	Infection probably through the air.				Glands of muscles.	Pubic or udder glands.	Remarks.
			Other glands of head.	Mesen-teric glands.	Portal glands.	Liver.			Lungs.	Bron-chial glands.	Posterior mediastinal glands.	Pleura.			
Herd III.															
A (in milk).....	7			++					+++	+	++				
B (in milk).....	6½	+		+		+			++	++	++				
C (bull).....	(?)								+	++	++				
D (in milk).....	4½	+		++	++				++	++	++				
E (in milk).....	3½								++	++	++				
F (in milk).....	4										+				
G (in milk).....	6	+							++	+	++				Traumatic pericarditis, no acute inflammation.
H (not in milk).....	3½								++	+	++				
I (in milk).....	4½								+	+	++				
J (in milk).....	2½			+					+	+	++				
K (not in milk).....	2								+	+	++				
L (not in milk).....	1½			+					+						
Herd IV.															
A (in milk).....	4									+	++				
B (in milk).....	6									+	++				
C (in milk).....	9									+	++				
D (in milk).....	3½	+		++	++				++	++	++				
E (not in milk).....	2								+						
F (in milk).....	1½								++	++	++				
G (in milk).....	6			++					++	++	++				
H (in milk).....	8								++	++	++				
I (in milk).....	11			++					++	++	++		+		Generalized disease.

Traumatic pericarditis, no acute inflammation.

Generalized disease.

Two shoulder and one knee-fold gland.

++ and trachea

(d) Whitewash is not in itself of sufficient strength to destroy tubercle bacilli, but by imprisoning and incrusting them on the walls of stables they are made harmless until destroyed by prolonged drying. Whitewashing should be preceded by thorough cleansing.

Particular attention should be paid to the sides and ceiling of stable. All dust and cobwebs should be periodically washed down. Those parts coming in contact with the heads of cattle, stanchions, halters, troughs, etc., should be frequently cleansed and disinfected, even when they have not been used by avowedly diseased cattle.

The removal of virus from the stables should furthermore be promoted by the prompt removal of manure and by abundant ventilation. Good air has the effect of diluting infected air and thereby reducing the chance of inhaling dried, floating tubercle bacilli, or at least of reducing the number to be inhaled. It likewise improves the vigor of the confined animals and hence increases the resistance to infection.

Cattle should not be placed so that their heads are close together; each animal should have plenty of room,* and occupy the same place in the stable at all times. These precautions will prevent the nasal, lung, or vaginal discharges of one animal from striking the head or soiling the feed of another. It is true that it is impossible to prevent animals licking each other, but it should be remembered that prevention must begin with the removal of all cases which are suspected of discharging tubercle bacilli. Stables should, furthermore, be carefully protected from the expectorations of human beings affected with tuberculosis of the lungs.

Cattle should be housed as little as possible. The pasture has the effect of greatly reducing the chances of infection by a more or less rapid destruction of the virus, as well as by increasing the vigor of the animals through muscular exertion in fresh air. To what extent animals may pick up the virus on fields it would be difficult to estimate. That it is perfectly possible can not be gainsaid. A tuberculous animal may soil the ground over which it passes, and other animals may take up the virus with the food soon after.

It is not likely that the virus remains alive long enough on the ground to become dried and ready for inhalation. The action of sunlight, the alternate wetting and drying which goes on in nature, may be looked upon as destructive agents. Even if the tubercle bacilli became speedily dried, the great diluting effect of the open air would reduce to a minimum the chances of inhaling the virus.†

Among the other dangers to caution against is the infection of food and water. Drinking troughs should be so arranged that the surface

*Each cow should have at least 600 cubic feet of air space.

†If infection takes place in the open air, it would probably be food infection. Observers in making autopsies of cattle living chiefly out of doors should pay particular attention to the primary focus of infection, in order that some positive information on this important subject may be obtained.

ease destroys the body? These are vital questions, and their answer must have an important modifying influence on the future success of dairying and stock-raising. As we are now entering upon an era of suppression of this disease, it should be borne in mind that radical measures are the best to begin with, and that after the disease has been weeded out of each large herd by tuberculin one or more times such herd becomes, in a sense, an experiment in the prevention of this disease, with the element of contagion presumably completely eliminated. The future will then decide how much is to be feared from the lapses of tuberculin, from sources of the virus outside of the bovine species, and from heredity, breed, and environment as predisposing agents.

TUBERCULOSIS AND THE PUBLIC HEALTH.

Much of the difficulty which arises when radical measures for the suppression of this disease are discussed is the economic value of the products of cattle, the meat and the milk. The somewhat heterogeneous views prevailing in this country concerning the use of the flesh of animals having but trifling tuberculous lesions are offset by the pretty definite attitude of European authorities, who claim that the meat from incipient cases of tuberculosis is entirely fit for food. This attitude enables Nocard in his recommendations to suggest the prompt fattening of all infected animals for the butcher. This difficulty has been solved temporarily in this country by turning the flesh of cattle which gave a reaction after the tuberculin test, even when the lesions were insignificant, into fertilizers. How far such destruction of food is called for in the interests of sanitation and sentiment is a question which must be left for future discussion and the wealth of the country to settle.

The use of the milk from infected animals is a question difficult to deal with when we consider on the one hand the clamors of public health and on the other those of the dairyman who finds it temporarily impossible to maintain his business if a large number of animals are at once withdrawn from his herd. It will be observed that Nocard does not forbid the use of the milk of incipient cases. Here also he avoids the stumbling block of reform in dairy matters by not making restrictions unnecessarily severe.

In order to obtain more information on the presence of tubercle bacilli in milk the work reported by Dr. Schroeder on pages 75 to 87 was undertaken as a continuation of former investigations already published in Bulletin No. 3. These investigations, so far as they refer to single animals, confirm those of all former observers, that the milk of tuberculous animals is not so frequently infected as has been supposed. It may be laid down as a general rule that the milk of animals in the earliest stages of tuberculosis and with perfect udders does not contain tubercle bacilli. Only such as show signs of labored breathing and emaciation, such as have enlarged external glands, or some difficulty

TABLE I.—*Distribution of tuberculous lesions in herra I (District of Columbia).*

Number.	Age.	Infection probably through food.*				Infection through the air.				Public or udder glands (milk glands probably infected at some time).	Remarks.		
		Retro-pharyngeal glands.	Other glands of head.	Mesenteric glands.	Portal glands.	Liver.	Peritoneum.	Uterus.	Lungs.			Bronchial glands.	Posterior mediastinal glands.	Glands of muscles.	Pleura.
		R.	L.										
301	4				+	+				++	+	++	
302	5									++	+	+++	
303	5				+	+				+++	+	++	Infection probably generalized.
304	5												
305	5				+								
306	6				+	+				++	+	+	
307	4									++	+		
308	2									+			
309	2												
310	14	+								+		+	
311	7			+						+	+	++	
312	6									+	+	++	Traumatic pneumonia.
313	6									+			
314	6			+	+					+++ and bronchi.	+	+	
315	6	+	+										
316	6												
317	3										+	+	
318	1				+					+	+	++	
319	1									+		++	
320	24												
321	3												
322	1												
323	24										+	+	
324	3				+					++	++	+	
325	3									++	++	+	
326	4									++	++	+	
327	3									++	++	+	
328	3	+	+							+			
329	12												
330	6									+			

* In these tables no attempt is made to separate those cases in which the infection of the digestive tract may have been secondary to disease of the lungs. Hence the percentage of food infection here indicated may be somewhat higher than is actually the case.

percentage
of food
infection

Traumatic
pneumonia.

Infection proba-
bly generalized.

TABLE II.—*Distribution of tuberculous lesions in a portion of herd II (New York).*

Number.	Age.	Infection probably through the food.				Infection probably through the air.				Remarks.					
		Retro-pharyngeal glands.	Other glands of head.	Mesenteric glands.	Portal glands.	Liver.	Peritonum.	Uterus.	Lungs.	Bronchial glands.	Posterior mediastinal glands.	Pleura.	Glands of muscles.	Pubic glands (milk infected at some time).	
		R.	L.												
586	5														
587	15			++	+				++	+	++	++	Right preescapular, right axillary.		Infection generalized.
588	11		Submaxillary	++					++	+	++	++			
589	8	+	do.	++	+		+++	+	+++	+	++	++			
590	4	+		+					++	+	++	++			
591	4	+		+					++	+	++	++			
592	4	+		+					++	+	++	++			
593	4	+		+					++	+	++	++			
594	5	+		+					++	+	++	++			
595	4	+		+	+	+	+		++	+	++	++			
596	4	+		+	+	+	+		++	+	++	++			
597	4	+		+	+	+	+		++	+	++	++			
598	4	+		+	+	+	+		++	+	++	++			
599	4	+		+	+	+	+		++	+	++	++			
600	3		Submaxillary	++	+				++	+	++	++			
601	4			++	++	++			++	+	++	++			
602	3	+	Parotid	+	++	++			++	+	++	++			
603	2			+	++	++			++	+	++	++			
604	4	+		+	+	+			++	+	++	++			
605	4	+		+	+	+			++	+	++	++			
606	4	+		+	+	+			++	+	++	++			
607	4	+		+	+	+			++	+	++	++			
608	4	+		+	+	+			++	+	++	++			
609	4	+		+	+	+			++	+	++	++			
610	4	+		+	+	+			++	+	++	++			
611	4	+	Left parotid and submaxillary.						++	+	++	++			
612	2								++	+	++	++			
613	2								++	+	++	++			
614	2								++	+	++	++			
615	2								++	+	++	++			
616	2	+							++	+	++	++			
617	1	+		+	+	+			++	+	++	++			
618	3	+							++	+	++	++			
619	2								++	+	++	++			
620	2								++	+	++	++			
621	1	+	Submaxillary	+		+			++	+	++	++			
622	1								++	+	++	++			
623	1	+		++	+	++			++	+	++	++			
624	1								++	+	++	++			
625	1			++	+	++			++	+	++	++			
626	1			++	+	++			++	+	++	++			
627	1			++	+	++			++	+	++	++			
628	1			++	+	++			++	+	++	++			
629	1			++	+	++			++	+	++	++			
630	1			++	+	++			++	+	++	++			
631	2			++	+	++			++	+	++	++			
632	2			++	+	++			++	+	++	++			
633	2			++	+	++			++	+	++	++			
634	2			++	+	++			++	+	++	++			
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717	2			++	+	++			++	+	++	++			
718	2			++	+	++			++	+	++	++			
719	2			++	+	++			++	+	++	++			
720	2			++	+	++			++	+	++	++			
721	2			++	+	++			++	+	++	++	</		

TABLE III.—*Distribution of tuberculous lesions in portions of heads III and IV (New York).*

Case.	Age.	Retro-pharyngeal glands.	Infection probably through the food.					Infection probably through the air.					Public or soldier glands.	Remarks.	
			Other glands of head.					Infection probably through the air.							
			Mesenteric glands.	Portal glands.	Liver.	Peritonaeum.	Uterus.	Lungs.	Bronchial glands.	Posterior mediastinal glands.	Pleura.	Glands of muscles.			
<i>Head III.</i>															
A (in milk).....	7		++					++							
B (in milk).....	6	+	+		+			++							
C (bull).....	3							+							
D (in milk).....	4	+	+					++							
E (in milk).....	3							++							
F (in milk).....	4							++							
G (in milk).....	6	+						+							
H (not in milk).....	3							+							
I (in milk).....	4							+							
J (in milk).....	2		+												
K (not in milk).....	2														
L (not in milk).....	1		+					+							
<i>Head IV.</i>															
A (in milk).....	4														
B (in milk).....	6														
C (in milk).....	9														
D (in milk).....	3	+	++												
E (not in milk).....	2		++					+							
F (in milk).....	14							++							
G (in milk).....	6		+					++							
H (in milk).....	8		+					++							
I (in milk).....	11		++					++ and trachea.							
Generalized disease.															
Two shoulder and one knee-fold gland.															
+ +															

Traumatic pericarditis, no active inflammation.

Generalized disease.

Two shoulder and one knee-fold gland.

TABLE IV.—*Distribution of tuberculous lesions in a portion of herd T (Virginia).*

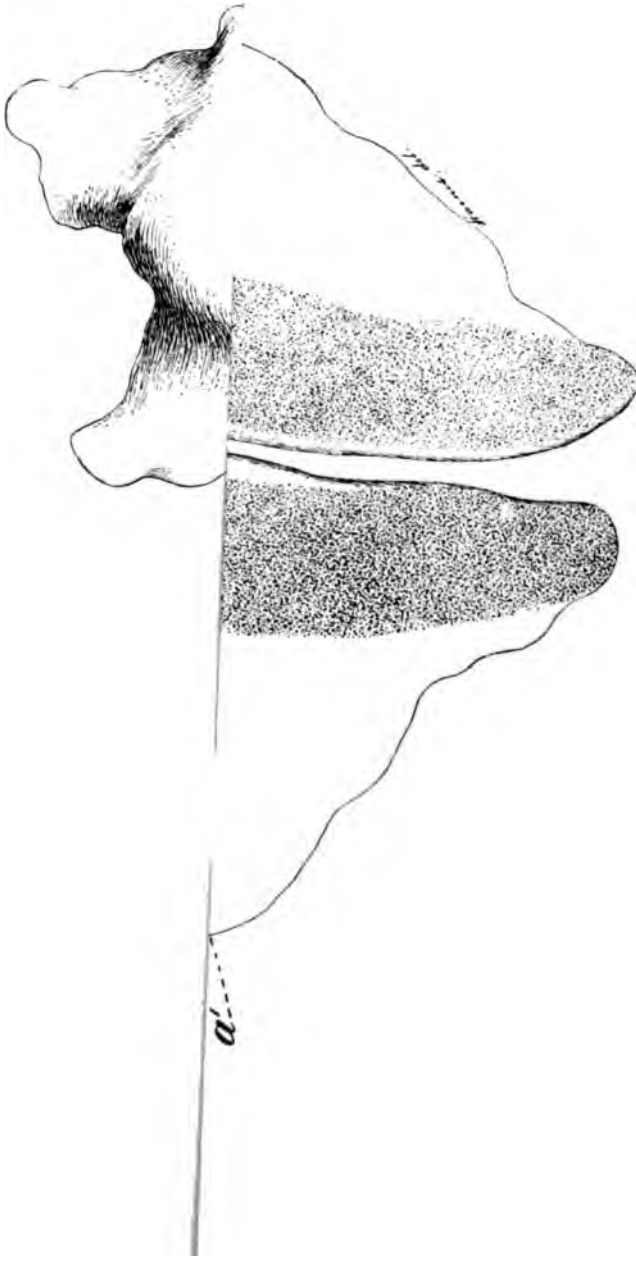
Case.	Age.	Retro-pharyngeal glands.		Infection probably through the food.				Uterus.	Infection probably through the air.			Glands of muscles.	Pubic glands (udder glands).	Remarks.
		R.	L.	Other glands of head.	Mesenteric glands.	Portal glands.	Liver.		Lungs.	Bronchial glands.	Posterior mediastinal glands.	Pleura.		
A (in milk).	6	+	+					+	++	+	++		++	Extensive tuberculosis of right half of udder. Tuberculosis of renal glands; tuberculous foci in spleen (generalized, probably congenital tuberculosis). Tuberculosis of trachea, kidneys (generalized infection).
B (calf)	3			Submaxillary, postmaxillary.	+++	+++	+		+	+	++	+++		
C	3	+	+	Tonsilla, post-maxillary.	+++	++	+++	+ and pelvic gland.	+++	+	++	++		
D	2								+					
E	2	+	+	Tonsilla	+						++			
F	2	+	+						+	+	+			
G	2	+	+	Both tonsilla, both postmaxillary.					+	+	+			Traumatic pneumonia. Tubercles in spleen (generalized infection).
H	2	+	+						+	+	+			

TABLE V.—*Distribution of tuberculous lesions in miscellaneous cases from various herds.*

Case.	Age.	Infection probably through the feed.			Infection probably through the air.				Public glands (udder glands).	Remarks.			
		Retro-pharyngeal glands.	Other glands of head.	Mesenteric glands.	Portal glands.	Liver.	Peritoneum.	Lungs.			Bronchial glands.	Posterior mediastinal glands.	Pleura.	Glands of muscles.
No. 237.		+		++	+	++	+++ and retro-peritoneal glands.	++	++	++	+		
No. 238.		+	Both submaxillary.	++	+	++		++	++	++	+		
No. 239.			Middle tracheal gland.	+				++	++	++			
No. 266.													
No. 268.	5	+		+	++	+		++	++	++	+		
No. 268a (calf of No. 268).	21				++	+				++			
No. 276.	3	+	Both tonsils.	+	+	+	+++	+++	+++	+++	+++		
No. 283.		+	Left tonsil.	++	+	+		+++	+++	+++	+		
No. 286.		+		++				+++	+++	+++	+		
No. 291.	4	+		++	+	+		+++	+++	+++			
No. 292.	10	+	Right tonsil and postmaxillary.	+				+		+			

Died of parturient apoplexy. Tubercles in kidneys and renal glands; infection generalized. Tubercles in spleen and one kidney. Intra-uterine infection. Foci in spleen, kidneys (generalized infection). Tubercle bacilli in milk. (See p. 82.)

Traumatism of second stomach, with abscesses in connective tissue. Right retropharyngeal very large, discharging through opening into posterior nasal passage; aspiration pneumonia.



DORSAL ASPECT OF THE BOVINE LUNGS. ($\times 2$).

PLATE II.—*Ventral aspect of the bovine lungs.*

The letters correspond to those on Plate I.

*a, a*₁, right and left caudal lobes.

*b, b*₁, right and left ventral lobes.

*c, c*₁, first and second right cephalic lobes.

*c*₂, left cephalic lobe.

d, azygos or median lobe (belonging to the right lung). This lobe is involved in the most advanced cases only.

e, trachea.

x, usual location of the earliest lesions of tuberculosis.



VENTRAL ASPECT OF THE BOVINE LUNGS. ($\times 1$).

PLATE IV.—*Dorsal aspect of the bovine lungs showing the position of the posterior mediastinal glands.*

*a, a*₁, caudal lobes.
*b, b*₁, ventral lobes.
*c, c*₁, *c*₂, cephalic lobes.

e, trachea.

f, œsophagus.

g, muscular pillars of the diaphragm.

h, posterior aorta cut through just beyond the arch and reflected so as to uncover the left bronchial gland A, resting against the root of the left bronchus.

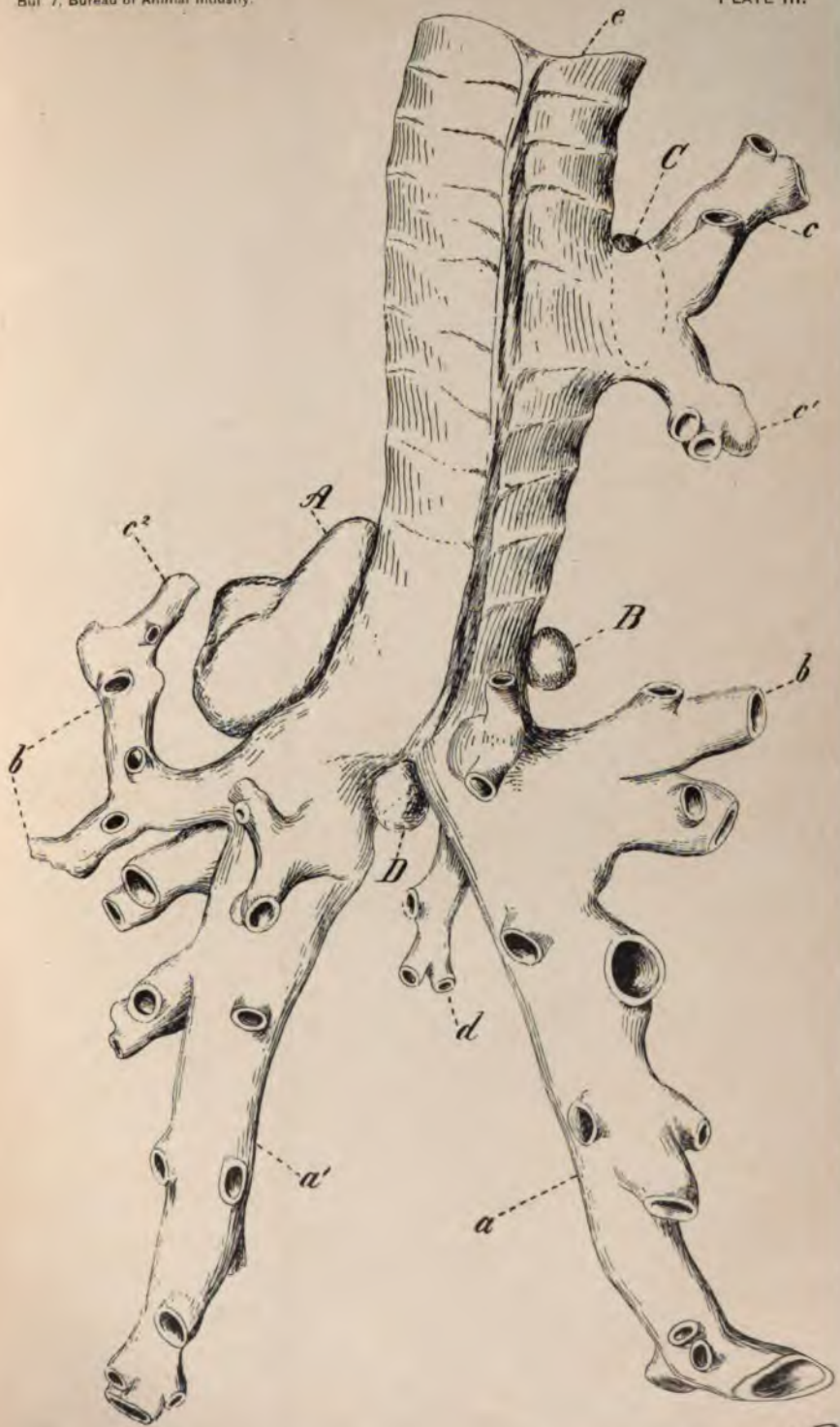
i, caudal margin of the ligament of the lungs (*ligamentum latum*.)

The mediastinal glands are shown, most of them resting on the œsophagus. The aorta, fat, and pleural layers which inclose the posterior mediastinal space laterally, are removed.

α , the large caudal gland resting below the œsophagus on the pillars of the diaphragm. This gland may be left in the body when the lungs and heart are removed unless special care is taken.

The remaining mediastinal glands are arranged in two sets, on the right and the left margin of the œsophagus. In this animal there is but one gland in the left chain. α is the gland most frequently diseased and in many cases enormously enlarged.

α_1 , the most cephalic of the mediastinal series.



TRACHEA AND BRONCHIAL TUBES OF THE BOVINE LUNGS, SHOWING ATTACHMENT OF GLANDS. ($\times 3$).



PLATE IV.—*Dorsal aspect of the bovine lungs showing the position of the posterior mediastinal glands.*

*a, a*₁, caudal lobes.

*b, b*₁, ventral lobes.

*c, c*₁, *c*₂, cephalic lobes.

e, trachea.

f, œsophagus.

g, muscular pillars of the diaphragm.

h, posterior aorta cut through just beyond the arch and reflected so as to uncover the left bronchial gland A, resting against the root of the left bronchus.

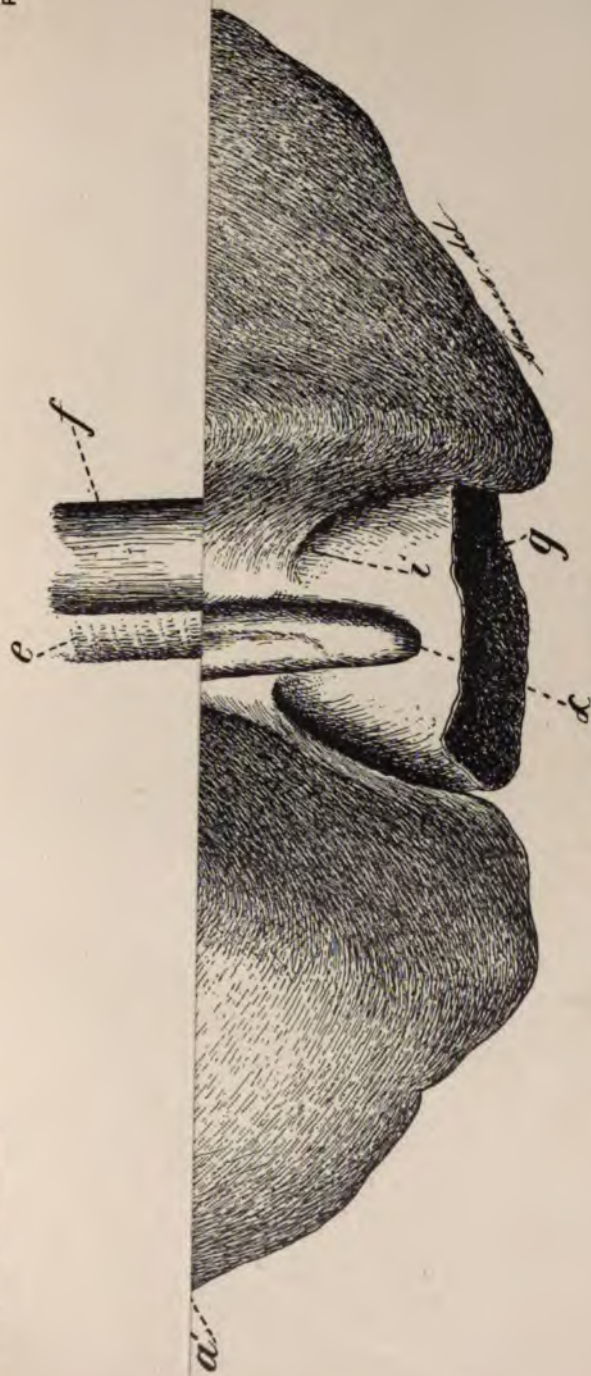
i, caudal margin of the ligament of the lungs (*ligamentum latum*.)

The mediastinal glands are shown, most of them resting on the œsophagus. The aorta, fat, and pleural layers which inclose the posterior mediastinal space laterally, are removed.

α , the large caudal gland resting below the œsophagus on the pillars of the diaphragm. This gland may be left in the body when the lungs and heart are removed unless special care is taken.

The remaining mediastinal glands are arranged in two sets, on the right and the left margin of the œsophagus. In this animal there is but one gland in the left chain. α is the gland most frequently diseased and in many cases enormously enlarged.

α_1 , the most cephalic of the mediastinal series.

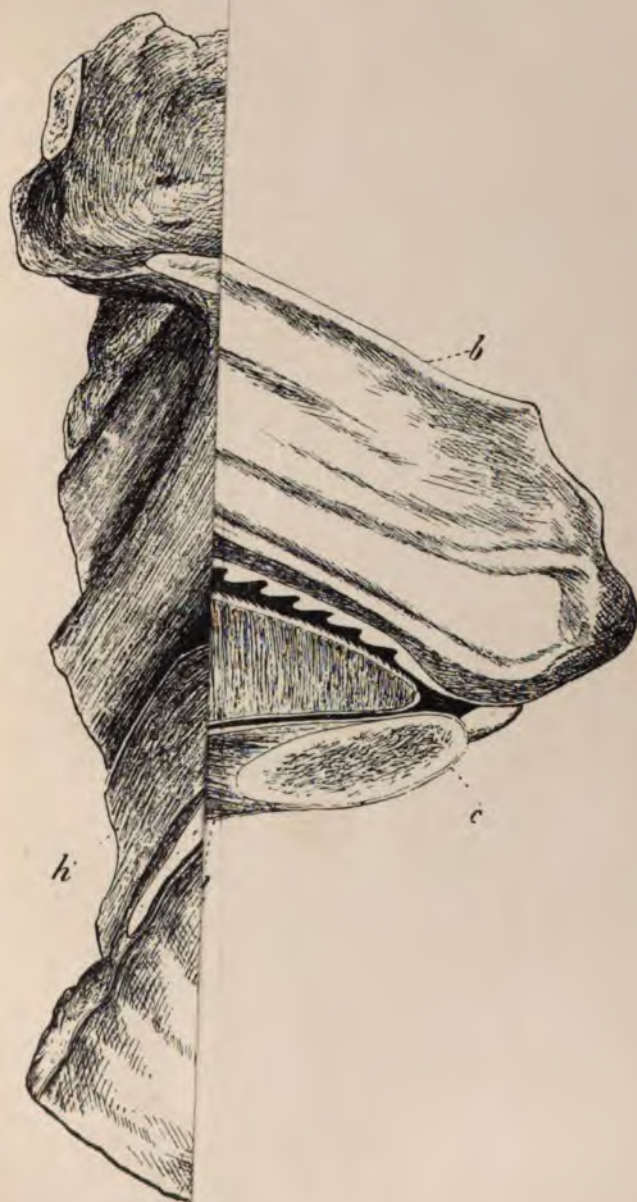


POSTERIOR MEDIASTINAL GLANDS. (x 2).

PLATE V. $\rightarrow$ Section through the median plane of the head of a cow to show location of the (left) retropharyngeal gland.

- a*, brain cavity.
- b*, nasal septum.
- c*, lower jaw, sawn through.
- d*, tongue.
- e*, posterior nasal passage.
- f*, trachea.
- g*, epiglottis, resting against soft palate.
- h*, oesophagus.
- A*, left retropharyngeal gland, in this case enlarged to twice the normal size by tuberculous deposits.

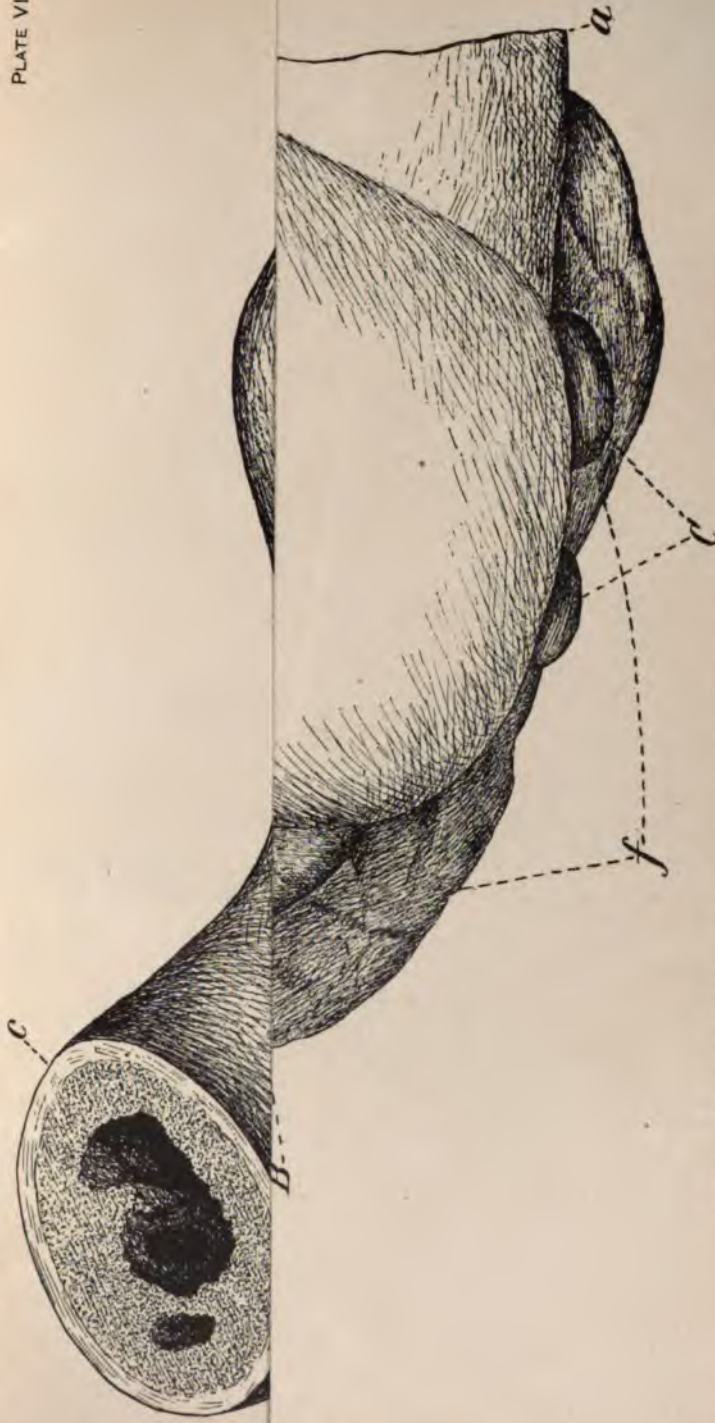
The opening into the left tonsil is shown as a dark spot under the soft palate. The tonsil itself is situated beneath the mucous membrane, where the cut surface of the palate appears and projects slightly above this, so as to lie in part under the mucosa of the posterior nasal passage.



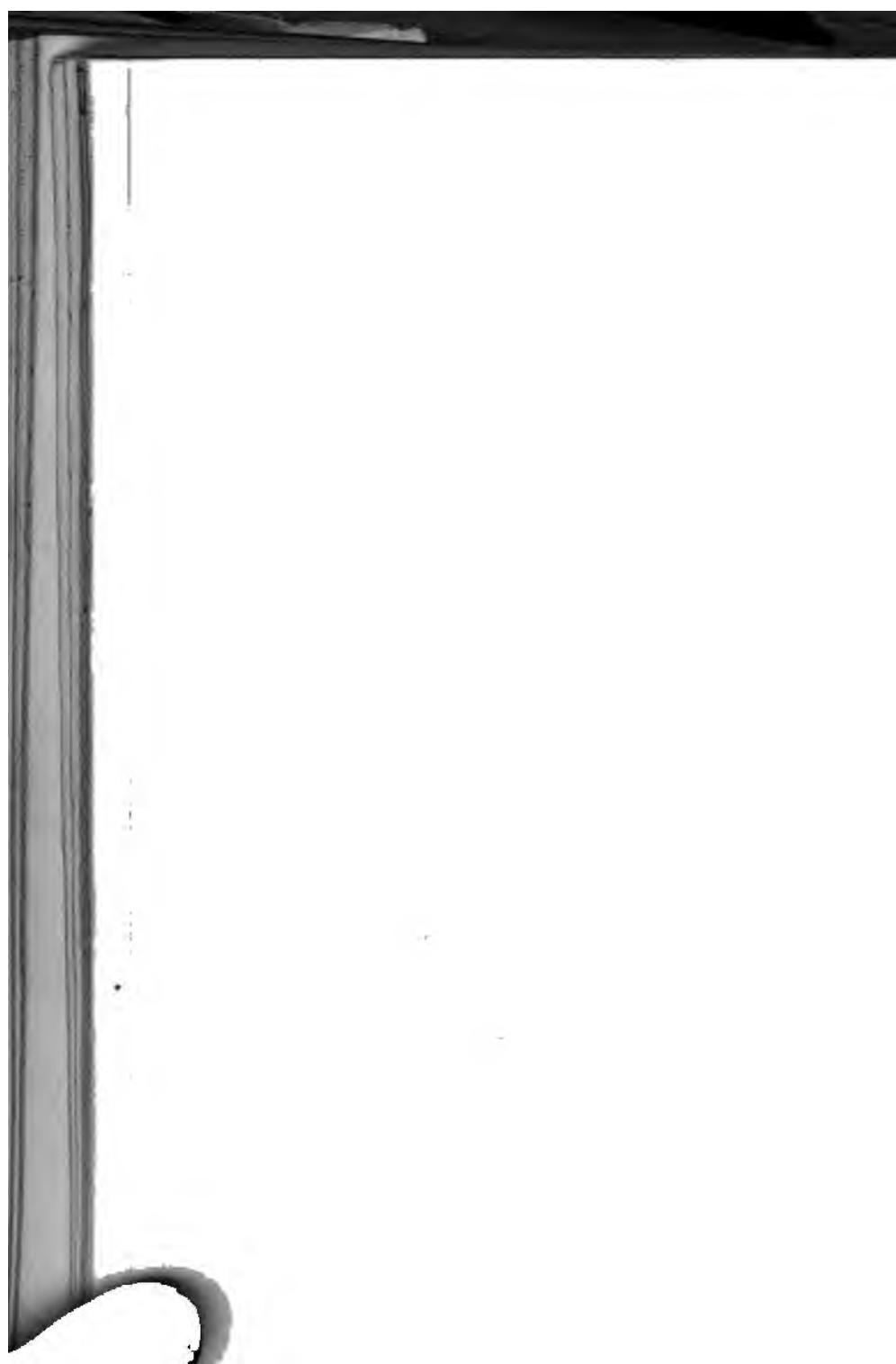
LYMPH GLAND. ($\times \frac{1}{2}$).

PLATE VI.—*Right lateral aspect of posterior half of a steer's head with skin and superficial fat removed to show location of lymph glands. (x ½.)*

- a*, lower jaw.
- b*, ear passage.
- c*, horn, sawn through near base.
- d*, styloid process of occipital bone.
- e*, parotid salivary gland.
- f*, submaxillary salivary gland.
- A*, right parotid lymph gland, partly hidden under the anterior border of the parotid salivary gland.
- B*, right post-maxillary lymph glands, the greater portion concealed beneath the submaxillary salivary gland.
- C*, right submaxillary lymph glands between ramus of lower jaw and submaxillary salivary gland.



LATERAL ASPECT OF POSTERIOR HALF OF A STEER'S HEAD TO SHOW LOCATION OF LYMPH GLANDS. ($\times 16$.)



LETTER OF SUBMITTAL.

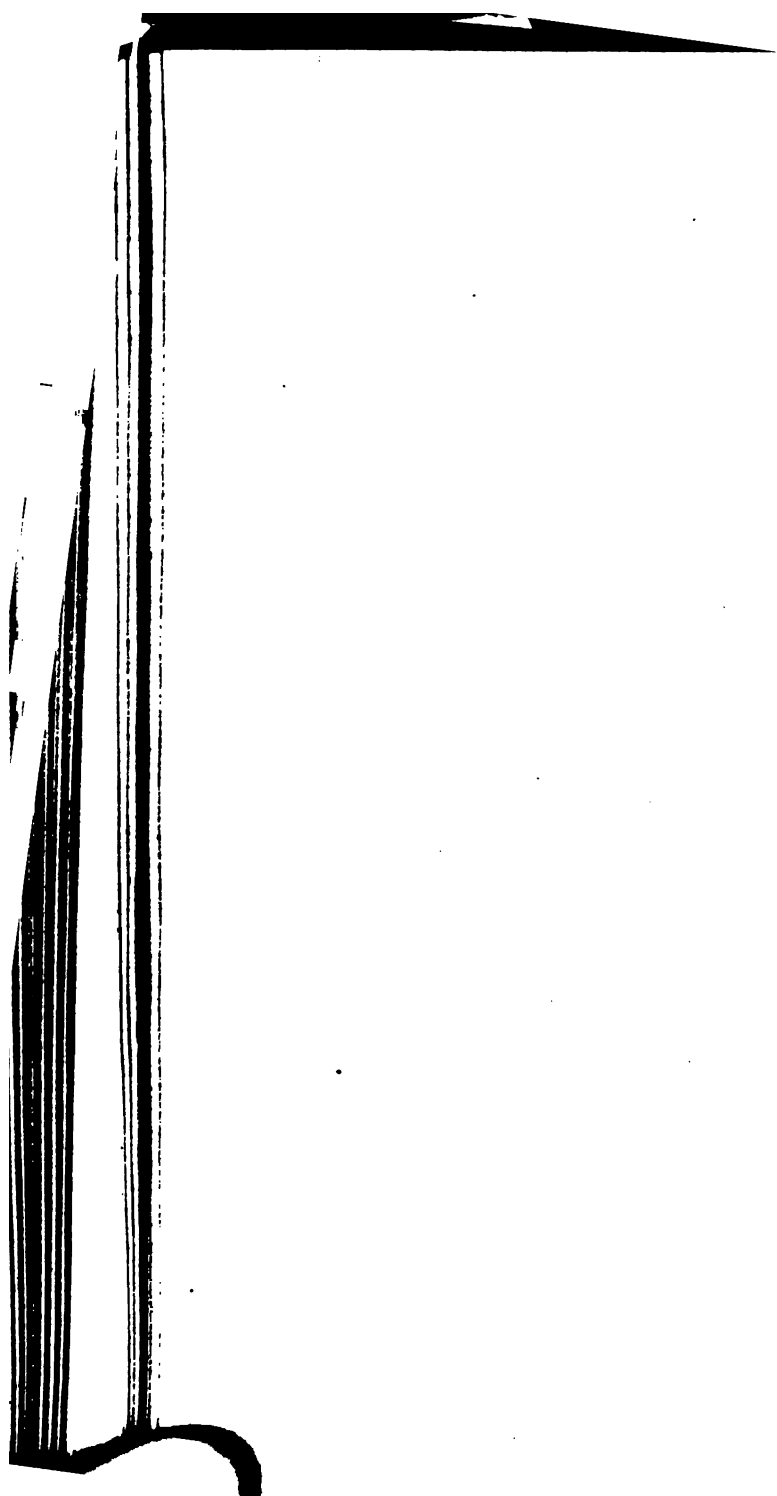
U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF ANIMAL INDUSTRY,
BIOCHEMIC LABORATORY,
Washington, D. C., July 1, 1894.

SIR: I herewith submit a few points of general interest with reference to tuberculin, its composition, use, and effect on the milk when injected into cows.

Respectfully,

E. A. DE SCHWEINITZ,
Chemist of Bureau of Animal Industry.

DR. D. E. SALMON,
Chief Bureau of Animal Industry.



TUBERCULIN AND ITS USE.

By E. A. DE SCHWEINITZ, PH. D.

As the use of tuberculin upon man proved more or less disappointing, due in a measure to its improper application, attention was turned to its value as a diagnostic agent for tuberculosis in cattle.

The preliminary tests made in France and Germany showed that tuberculin was a fairly reliable agent. This indicated that if properly applied tuberculin might be useful in indirectly checking and controlling consumption in man by paying due attention to its distribution among animals. Accordingly, about three years ago, experiments in its manufacture and use were begun in the Biochemic Laboratory in Washington. The preliminary and comparative tests with this and the tuberculin manufactured in Europe proved the Bureau tuberculin to be equally reliable, as will be seen from the accompanying report of comparative tests made at the Wisconsin Station by Dr. Russell.

In order to attract attention to the prevalence of tuberculosis in cattle, the resulting dangers to man, and the value of tuberculin in controlling it, the Bureau of Animal Industry offered to supply the boards of health and State experiment stations with this material, to be used in diagnosing disease, provided reports were made of the results obtained. The demand for the tuberculin increased very rapidly, requests coming from all parts of the United States, Canada, and the West Indies.

During the six months, beginning January 1, 1894, there has been manufactured and distributed from the Biochemic Laboratory of the Bureau, tuberculin sufficient for about 4,600 injections, which, at the price charged in New York for Koch's tuberculin, would have cost about \$3,500. This does not include the tuberculin used by the Bureau for testing some special herds, which would be about 300 injections more. The Bureau has also been supplying mallein for the diagnosis of glanders, the use of which has proved exceedingly valuable. This will be referred to in detail in another bulletin.

The tuberculin prepared by the Bureau is always tested on tuberculous cattle in order to have, as far as possible, a uniform material, so that results from different localities can be satisfactorily compared.

Reports of the results of the injection and post-mortem notes have been received from a number of different parties, the largest number from the experiment station of Vermont and board of health of Massachusetts. In all cases where the animals showed a characteristic reaction and were killed, the autopsy proved the presence of tuberculosis.

The report made by Dr. Russell upon the comparative value of the Bureau and Koch tuberculin, the results of which are appended in Tables VII and VIII, was as follows:

The number of animals selected for the test was 18, mostly high-grade stock. The herd was divided into two equal parts and the one lot injected with the Bureau tuberculin, the other with the imported article. After four to seven weeks the injections were repeated, the order of procedure being changed. Those that had received the imported product were given the Bureau tuberculin and those that had received the Bureau tuberculin were given the imported product.

Out of a possible 15 cases, as two animals of the herd did not react with either injection and were not slaughtered and one animal was excluded by an accident in the experiment, the Bureau tuberculin gave 14 correct diagnoses. In one case (Beauty), neither the Bureau nor the imported tuberculin showed a reaction, though autopsy proved the presence of tuberculous lesions. In 4 cases, Gay, Aggie, Galena, and Daisy, the second injection with the imported tuberculin failed to show a reaction, though the first injection with the Bureau tuberculin had shown a marked reaction, which was confirmed by the autopsy. This lack of reaction from the Koch tuberculin may have been due to the fact that the amount of tuberculin was not as strong as that used on the first injection, though in two similar cases, Polly and Melvina, the same quantity of Koch tuberculin showed a good reaction upon the second injection, after a marked reaction had been shown by the first injection with Bureau tuberculin. These tests have shown again the entire reliability of the Bureau tuberculin.

By some a decided local reaction has been noted at the point of inoculation of tuberculin. Dr. Russell reports that where care was used in sterilizing the syringe no irritation resulted. Unless such precautions are observed, therefore, any local reaction is to be attributed, not to tuberculin, but to septic infection.

In a great many instances the disease is found to be but slightly advanced in a number of animals, so that the milk from such animals would not necessarily be injurious. This, however, could be proven only by careful examination and inoculation experiments.

That tuberculin has some curative properties is undoubtedly proved and these might be utilized to advantage in many instances. In March two tuberculous cows were brought to the station for experiment. In one the disease had been diagnosed by Dr. Schroeder upon physical examination and both had responded to the tuberculin test. One of these, No. 286, was with calf at the time, which she subsequently dropped and it was to all appearances in perfect health.

The milk from this cow used for the inoculation of guinea pigs by Dr. Schroeder caused the death of a number of the animals, but not from tuberculosis. No tubercle bacilli could be detected by centrifugalizing and subsequent microscopical examination of the milk. The calf was kept for several months, all the time with the mother, and

had all the milk. After two months she received an injection of 0.75 cc. tuberculin, but failed to show any reaction. The mother showed a reaction upon the first and a slight reaction upon the second injection, a marked reaction upon the third, and upon subsequent injections a slight reaction. On the contrary, No. 285, which had shown a high reaction upon the first injection, gave but a slight reaction on the second, and subsequent thereto no reaction at all, as can be seen from the Tables I and V. The animal was thrifty and apparently in fairly good health and had improved since brought to the station. It will receive more injections of tuberculin, but has to all appearances been benefited by the action of the tuberculin.

Now, as to the nature of the active principle of tuberculin, the investigations of Kühne, especially, have shown that as ordinarily prepared, the culture fluid contains so much peptone, with which there is always more or less albumose, that it is impossible to separate the true products of the bacillus from the other substances present in the culture media. The simplest way to avoid this difficulty, which was also encountered by the writer, is by the use of fluid for the cultivation of the bacillus in which glycerin, mineral salts, and asparagin or urea were the food for the germs.

I have used two formulas, both of which have given fairly satisfactory results in regard to growth:

- | | |
|--------------------------------|-----------------------------|
| 1. Water, 1,000 cc. | 2. Water, 1,000 cc. |
| Glycerin, 70 grams. | Glycerin, 70 grams. |
| Acid pot. phosphate, 1.0 gram. | Sodium chloride, 6 grams. |
| Am. phosphate, 10 grams. | Calcium chloride, 0.1 gram. |
| Sodium chloride, 10 gram. | Mag. sulphate, 0.3 gram. |
| Asparagin, 2 grams. | Ac. pot. phos., 2.5 grams. |
| Mag. sulphate, 0.2 gram. | Am. lactate, 6.5 grams. |
| | Asparagin, 3 grams. |

After sterilization of the ripe artificial cultures, the germs were removed by filtration and the mineral salts by dialysis. The addition of absolute alcohol to the dialysed solution, free from mineral salts, produced a white flocculent precipitate. After drying in vacuo over sulphuric acid this was difficultly soluble in water, swelling up, partially soluble in dilute NaOH, insoluble in salt solution. Its water solution yielded a slight opalescence with nitric and acetic acid, and a precipitate with ammonium sulphate. The substance gave the biuret reaction as well as the xanthoproteic, but did not respond to Millon's test. It was free from ash, did not contain sulphur, but phosphorus, the latter combined in the molecule, as it was evident after boiling the substance with nitric acid.

The precipitate, therefore, would seem to belong to the class of the nucleo-albumins.

As there had not been a particle of albuminoid matter in the solution this was a purely synthetical product of the germ life.

The reaction of this nucleo-albumin was tested on a tuberculous guinea pig; 0.002 gram dissolved in water caused within six hours rise of temperature from 102.6° to 104° F.

The solution of the substance that passed through the dialyser contained at first only the mineral salts and some glycerin. After two days some of the albumin had passed through the membrane. The solution free from albumin failed to give any alkaloidal reactions, and produced no rise of temperature in tuberculous guinea pigs. Asparagin, as such, appeared to be no longer present in the solution, and the mineral phosphoric acid and nitrogen had become incorporated in the organic molecule. This is but a brief notice of a study of the active principle of tuberculin as prepared from artificial cultures, and is being pushed as rapidly as the difficulty and nature of the work will allow.

The danger of injecting tuberculin in healthy animals in moderate quantity is slight. In healthy guinea pigs I have found that an injection of a dose twenty times as large as that required to produce reaction in a diseased cow may kill, but will not always do so. There is no danger of infection if the tuberculin is properly prepared.

In order to see the effect, if any, in introducing tuberculin into the stomach we have fed tuberculous guinea pigs varying quantities of tuberculin. A dose of 0.5 cc. diluted tuberculin which, when injected will produce a rise of temperature 2.5° to 3° F., when fed to another pig in the same stage of the disease is without effect. If the dose be made twelve times as great there is a slight rise of temperature in four to six hours. Repeated daily feeding of small doses of tuberculin 2.5 cc., will cause a slight rise of temperature after the fourth day in tuberculous pigs, showing its action to be cumulative. Upon healthy pigs the larger dose is without effect. Such a quantity is entirely out of proportion to that which man or animals could get under any ordinary conditions, and from the appearance of the stomach in the guinea pigs the rise of temperature is due to the irritation rather than the dissemination of the tuberculin through the system.

Although the active principle of tuberculin is very resistant to the action of artificial digestion in a 0.2 per cent pepsin and 1 per cent hydrochloride acid solution, under the action of the different ferment and acids of the stomach it would probably be more rapidly decomposed. In the case of invalids and children there might be some irritating and poisonous action resulting from tuberculin.

Dr. Schutz* claims that the effect of tuberculin injection does not change the specific gravity of the milk.

We have made a few examinations of the milk from healthy and tuberculous cows taken the day before injection, the day of injection

*Arbeiten aus dem Kaiserlichen Gesundheitsamte, 1892, p. 40, Vol. XIII.

when the temperature was about at the maximum, and the day or two after injection as shown in the tables. Nos. 113 and 217 were healthy animals; Nos. 285, 286, 110, 290, tuberculous. Through an error on the part of an assistant the samples brought for analysis were, in Table II, the first portion of each milking, except in case of Nos. 286 and 113, where the entire amount was saved. The error was not discovered until too late to make the corrections with these animals, but the results are comparative.

In the results noted in the other tables the analyses were made from the entire milking. Cows Nos. 285, 286, 217, and 113 were ordinary animals. No. 290 was a Jersey. In this work I have been ably assisted by Mr. J. A. Emery, who has made a large proportion of the milk analyses.

The Tables IV and VI show that the acidity of the milk from the tuberculous cows was less than that from the healthy, and the amount of volatile fatty acids was decidedly less. This can not be attributed to the breed of the animal, as No. 290, a Jersey, shows almost as low as No. 285. The figures for volatile fatty acid are calculated on the number of cubic centimeters of $n/10$ $Ba(OH)_2$ solution required for the neutralization of the volatile acids from 1 gram of fat of each sample. Table VI shows the average daily variation in the milk of the animals Nos. 285, 217, and 290 under normal conditions, while Tables II, III, and IV show the changes in the milk constituents under the action of the tuberculin.

In Tables I and V are given the temperatures of the individual animals during the tests with tuberculin on the dates corresponding to those upon which the milk was collected for analysis.

In general, the results show a decrease in total solids in the tuberculous animals after the injection. In the healthy animals there is also a slight decrease in solids but not as much as in the diseased animals.

There is also a decided variation in the proportion of fat before and after injection of the tuberculin as well as albuminoids and sugar. The fat and sugar decrease, the albuminoids show a slight increase. The latter may, in part, be attributed to the presence of a small amount of tuberculin in the milk. This variation in the constituents of the milk would indicate that, while under examination with tuberculin, the milk of the animals should either not be used at all, or close attention paid to the fact that tuberculin will cause such variations. These results are but preliminary to a more extended examination.

As the inspection of tuberculous animals continues, more careful examinations will be made of the milk, and other interesting questions relative to tuberculin and its effects will be studied.

RELATION BETWEEN THE TIME AFTER INOCULATION AND THE
REACTION WITH TUBERCULIN.

In order, if possible, to arrive at some idea as to the length of time after inoculation with tuberculosis before an injection with tuberculin would show a reaction, the following experiments were begun some time ago. These were interrupted but are being continued again. The result obtained with the first two sets of experiments may be recorded here, and will be found in Tables IX and X. Guinea pigs, about 1 pound in weight each, Nos. 421, 424, 425, 426, 429, and 430, were inoculated with tuberculosis from an emulsion of the surface growth of an agar culture in 10 c. c. P. b. b. on July 10, 1893. Nos. 427, 428, 431, 432, 433, 435, and 436 were reserved as checks.

The first injection was made July 13 with 0.25 c. c. tuberculin on No. 429, and a rise of temperature in three hours of 3.2° F. was noted. The animal showed at the point of inoculation with the germ a slight swelling, otherwise was apparently in good health. July 20, the injection upon No. 429 was repeated, 0.125 c. c. tuberculin being used, and Nos. 430 and 428 were also used. The check showed no rise of temperature while the inoculated ones showed a rise of about 1° F. each. This was ten days after the inoculation. July 21 and July 26 the injection was repeated on Nos. 429 and 430, respectively, with a rise of 1° F., but the checks still showed no reaction.

Nos. 425 and 426 on July 22, both of which had been inoculated on July 10 with the same amount of a culture of tuberculosis gave, when injected with tuberculin, a rise of 1.6° and 0.6° F., while the check showed a fall of temperature.

Tested again on July 29 both pigs showed about the same rise in temperature as before.

Nos. 424 and 425 when first tested showed about the same reaction as the others, the same number of days after injection, as did also No. 421, six days after the injection. No. 424 died from general tuberculosis on August 12, just two months after the inoculation. As it seemed from these injections that the tuberculin produced a reaction almost as soon as the germ was introduced into the system and before any local lesion, other than the inflammation set up at the point of inoculation could be formed, the experiment was repeated with results as recorded in Table X.

For this experiment pigs Nos. 482, 483, 485, and 486 were inoculated, and Nos. 481, 484, 487, and 488 retained as checks. They were inoculated October 7, 1893. October 26, pig No. 482, which had on October 25 shown a reaction with tuberculin, was chloroformed and examined. There were a few small tubercles in the lungs, otherwise the animal was apparently healthy. Five days after the inoculation the pigs showed a slight reaction; ten days after, no reaction; eighteen days after, no reaction. The first injection of tuberculin probably interfered with the others, and also retarded the advance of the disease.

No. 486 received the first injection of tuberculin eleven days after inoculation, but showed no reaction. When tested again, twenty-four days after, there was a rise of temperature of 1° only. Four months afterwards the pig was found dead, and although there were a few tubercles in lungs and liver, and the glands of the knee near the point of inoculation were tuberculous, the animal had died from other causes.

In the case of No. 483, the first injection, seven days after the inoculation, as well as the subsequent ones, eleven and twenty-four days after, showed a reaction of 1° . The pig was chloroformed on November 5, just one month after inoculation, but beyond a very slight swelling at the point of inoculation there was no sign of lesions. The injection with tuberculin had probably checked the disease. In the case of No. 485, the first injection with tuberculin showed a rise of 0.4° F. nine days after inoculation. The second, eighteen days after, a rise of 0.6° F., and one month after, a rise of 2° . The pig was found dead on December 8, two months after the inoculation. The glands at the knee-fold were enlarged and tuberculous, the lungs were hemorrhagic and contained a few tubercles; liver and spleen normal.

In two instances the checks gave a slight reaction upon the first injection with tuberculin, but when chloroformed immediately and examined seemed healthy, and their temperature before inoculation had been a little high.

Two guinea pigs that had been inoculated with tuberculosis on July 10 received an injection of tuberculin again on November 8, and showed a marked rise of temperature. They were both found dead a month later, and autopsy showed ulceration where inoculated, liver enlarged and fatty, lungs covered with tubercles.

These experiments tend to show that the reaction in temperature may be influenced by the location of the lesions. So far, however, in the examination of tuberculous cattle it has been impossible to show any fixed relationship between the character and extent of the tubercular lesion and the amount of reaction.

To see what lesions would be produced by infecting guinea-pigs with feeding them tubercle cultures, 5 pigs were selected, and on May 24, 1894, fed 0.5 and 1 c. c., respectively, of liquid tubercle culture. On June 22, 1894, 1 of these pigs was chloroformed. To outward appearances the animal was healthy. The autopsy showed the lungs to be congested and covered with a large number of incipient tubercles. The liver was soft and friable, and the spleen pale and covered with a number of tubercles. The stomach and intestines did not show any signs of tuberculosis.

On July 10 another one of this set of pigs was chloroformed. Autopsy showed about the same condition as the first one, viz, incipient tuberculosis in the spleen and lungs, but the other organs were apparently normal.

The 3 other pigs of this set were to all appearances perfectly healthy though they all had a high temperature, viz, 103.5°-104° F.

In the case of glanders Nocard has found that if the virus is introduced into the stomach with the food of the animal the disease develops rapidly, but the lesions will be found in the lungs and spleen with no sign of disease in the stomach. The tests on guinea pigs also point to the possibility of a similar action in the case of the tubercle bacillus when taken in through the alimentary tract.

TABLE I.—*Temperature reactions of cows on repeated injections of tuberculin*

	Healthy cows						Second-in
	Nos.—						tubercu
	Date.	Time.	113.	217.	Date.	Time.	cows N
							285.
			Temperature.				Temper
Day before injection.	1894.				1894.		
	Mar. 30	6 a. m.	101.2	101.5	Mar. 19	11 a. m.	102.3
	Mar. 30	8 a. m.	101.7	102.3	Mar. 19	1 p. m.	102.0
	Mar. 30	10 a. m.	101.8	102.2	Mar. 19	3 p. m.	102.0
	Mar. 30	12 m.	99.0	100.7	Mar. 19	5 p. m.	101.0
	Mar. 30	2 p. m.	100.7	101.4	Mar. 19	7 p. m.	101.7
	Mar. 30	4 p. m.	100.8	102.0	Mar. 19	9 p. m.	101.0
	Mar. 30	6 p. m.	101.0	102.5			
	Mar. 30	8 p. m.	100.8	101.7			
	Mar. 30	10 p. m.	100.5	101.0			
	Mar. 31	6 a. m.	100.5	101.4			
Injected 2 cc. tuberculin at 7 a. m. Injected 2 cc. tuberculin at 11							
Day when injected.	Mar. 31	10 a. m.	101.7	102.8	Mar. 20	6 a. m.	101.0
	Mar. 31	12 m.	101.4	101.4	Mar. 20	8 a. m.	101.4
	Mar. 31	2 p. m.	101.0	101.8	Mar. 20	10 a. m.	101.2
	Mar. 31	4 p. m.	101.5	102.5	Mar. 20	12 m.	101.2
	Mar. 31	6 p. m.	101.5	103.0	Mar. 20	2 p. m.	103.2
	Mar. 31	8 p. m.	100.0	100.7	Mar. 20	4 p. m.	108.5
	Mar. 31	10 p. m.	100.4	101.4	Mar. 20	6 p. m.	103.2
	Mar. 31	8 p. m.	100.8	101.4	Mar. 20	8 p. m.	103.2
	Apr. 1	8 p. m.			Mar. 20	10 p. m.	101.6
					Mar. 20	12 p. m.	100.8
				Reinjected at 12:15 a. m. with.....		Tubercu	
						6 cc.	
				Mar. 21		7 a. m. 101.2	
				Mar. 21		9 a. m. 101.8	
				Mar. 21		11 a. m. 101.0	
				Mar. 21		1 p. m. 101.4	
				Mar. 21		3 p. m. 101.2	
				Mar. 21		5 p. m. 101.2	
				Mar. 21		7 p. m. 102.0	
				Mar. 21		9 p. m. 101.4	
				Mar. 21		11 p. m. 101.0	
				Mar. 22		7 a. m. 101.0	

* Milk collected March 31 and April 1 at 7 a. m.

TABLE I.—*Temperature reactions of cows on repeated injections of tuberculin—Cont'd.*

	Date.	Time.	Sec- ond in- jection healthy cow No. 217.†	Third in- jection tuber- culous cows Nos.—		Date.	Time.	Tuberculous cows Nos.—	
				285.†	286.†			110.†	290.†
				Temperature.				Temperature.	
Day before injection.	1894.					1894.			
	Apr. 12	2 p. m.	97.2	98.8	101.2	Apr. 16	2 p. m.	100.5	.....
	Apr. 12	4 p. m.	98.7	100.0	101.8	Apr. 16	5 p. m.	99.8	.....
	Apr. 12	6 p. m.	101.6	100.5	102.8	Apr. 17	6 a. m.	100.8	.....
	Apr. 12	8 p. m.	101.2	101.0	102.8	Apr. 17	8 a. m.	100.4	.....
						Apr. 17	10 a. m.	101.4	.....
						Apr. 17	12 m.	100.5	101.0
						Apr. 17	2 p. m.	99.5	102.0
						Apr. 17	4 p. m.	99.7	101.8
						Apr. 17	6 p. m.	101.5	102.8
					Apr. 17	8 p. m.	101.0	101.5	
Injected 2 cc. tuberculin at 11 p. m.						Injected 2 cc. tuberculin at 11:30 p. m.			
Day when injected.	Apr. 13	6 a. m.	101.4	101.0	103.4	Apr. 18	6 a. m.	101.2	102.5
	Apr. 13	8 a. m.	102.2	101.4	103.2	Apr. 18	8 a. m.	101.0	103.0
	Apr. 13	10 a. m.	101.2	102.0	104.2	Apr. 18	10 a. m.	103.8	104.2
	Apr. 13	12 m.	102.0	101.0	104.5	Apr. 18	12 m.	105.8	105.0
	Apr. 13	2 p. m.	101.2	101.8	105.0	Apr. 18	2 p. m.	104.7	105.0
	Apr. 13	4 p. m.	101.2	101.7	105.2	Apr. 18	4 p. m.	105.7	105.4
	Apr. 13	6 p. m.	101.4	102.4	103.0	Apr. 18	6 p. m.	105.4	104.6
	Apr. 13	8 p. m.	101.2	101.8	102.6	Apr. 18	8 p. m.	104.0	104.6
						Apr. 18	11:30 p. m.	101.4	105.0
						Apr. 19	7 a. m.	100.0	102.8

† Milk collected at 5 p. m.

TABLE II.—*Percentage variation in the constituents of the milk from healthy and diseased cows produced by the injection of tuberculin.*

NO. 285.

Date.	Total solids.	Sugar.	Albu- mi- noids.	Fat.	Ash (in milk).	Ash (in total solids).	Chlo- rine (in milk).	Chlo- rine (ash).	Chlo- rine (total solids).	Remarks.
Mar. 19	14.48	3.33	3.15	8.19	.660	4.61	.010	1.55	.077	Before injection (injected 11 p. m., tuberculous.)
20	10.32	3.12	3.41	2.55	.692	6.71	.010	1.47	.098	After injection.
21	12.43	3.12	3.93	5.11	.732	5.88	.0046	.632	.037	Reinjected (12:15 a. m.).
22	11.25	2.72	3.75	5.12	.802	7.13	.016	2.09	.149	After reinjection.

NO. 286.

Date.	Total solids.	Sugar.	Albu- mi- noids.	Fat.	Ash (in milk).	Ash (in total solids).	Chlo- rine (in milk).	Chlo- rine (ash).	Chlo- rine (total solids).	Remarks.
Mar. 19	15.44	2.72	4.32	8.19	.661	4.28	.011	1.60	.066	Before injection (injected 11 p. m., tuberculous.)
20	13.51	2.72	4.23	6.12	.712	5.27	.005	.786	.041	After injection.
21	15.22	2.63	4.23	8.21	.724	4.71	.0049	.681	.032	Reinjected (12:15 a. m.).
22	13.50	2.50	4.50	6.13	.769	5.70	.015	2.04	.114	After reinjection.

NO. 112.

Date.	Total solids.	Sugar.	Albu- mi- noids.	Fat.	Ash (in milk).	Ash (in total solids).	Chlo- rine (in milk).	Chlo- rine (ash).	Chlo- rine (total solids).	Remarks.
Mar. 31	11.01	4.17	3.26	2.54	.775	7.03	.023	3.03	.213	Before injection (healthy).
Apr. 1	10.60	3.84	3.20	1.52	.696	6.53	.041	6.57	.429	After injection.

TABLE II.—Percentage variation in the constituents of the milk from healthy and diseased cows produced by the injection of tuberculin—Continued.

NO. 217.

Date.	Total solids.	Sugar.	Albuminoids.	Fat.	Ash (in milk).	Ash (in total solids).	Chlorine (in milk).	Chlorine (ash).	Chlorine (total solids).	Remarks.
Mar. 31	10.83	4.17	2.90	2.23	.723	6.67	.0023	.325	.0216	Before injection (healthy).
Apr. 1	10.38	4.16	2.89	2.54	.790	6.81	.072	3.75	.255	After injection.

NO. 286.

Apr. 12	16.24	1.92	2.44	(*)	.822	5.30				Before injection (tuberculous).
13	12.62	1.56	2.72	(*)	.720	5.70	.043	6.01	.343	After injection.

* Quantity of milk insufficient for a determination.

NO. 110.

Apr. 17	12.59	3.84	3.23	5.14	.672	5.33	.050	7.54	.402	Before injection (tuberculous).
18	12.58	3.84	3.20	4.12	.750	5.96	.081	8.17	.487	After injection.
19	10.52	3.84	3.19	3.08	.666	6.53	.056	8.10	.530	Second day after injection.

NO. 290.

Apr. 17	13.62	3.84	3.48	5.65	.684	5.04	.052	7.70	.388	Before injection (tuberculous).
18	15.31	3.57	3.25	7.23	.786	5.13	.089	11.43	.587	After injection.
19	11.23	3.57	3.43	3.08	.667	5.66	.051	7.71	.437	Second day after injection.

NO. 217.

Apr. 12	11.03	4.17	1.26	2.56	.681	6.17	.054	8.05	.497	Before injection (healthy).
13	9.77	3.57	1.39	1.53	.727	7.44	.060	8.35	.621	After injection.

TABLE III.—Percentage variation in the constituents of the milk from healthy and diseased cows produced by the injection of tuberculin.

NO. 286.

Date.	Specific gravity.	Total solids.	Ash (milk).	Ash (total solids).	Albuminoids.	Sugar.	Fat.	Remarks.
May 15	1.031	10.52	.711	6.75	2.89	3.84	3.05	Before injection of tuberculin.
16	1.029	11.13	.715	6.39	2.81	3.84	3.57	Do.
17	1.029	10.83	.728	6.93	2.71	4.16	2.55	After injection of tuberculin.

NO. 285.

May 16	1.024	17.01	.761	4.47	4.35	2.77	10.27	Before injection of tuberculin.
17	1.027	14.27	.718	5.23	4.01	3.12	6.03	After injection of tuberculin.

Increase after injection in sugar, ash, and specific gravity.

Decrease after injection in fat, albuminoids, and total solids.

TABLE IV.—Percentage variation in the constituents of the milk from healthy and diseased cows produced by the injection of tuberculin.

NO. 285.

Date.	Total solids.	Sugar.	Albuninoids.	Fat.	Ash (milk).	Acidity lactic acid	No. cc.		No. cc.	
							$\frac{n}{10}$ NH_4OH required for 1 cc. milk.	$\frac{n}{10}$ $\text{Ba}(\text{OH})_2$ for volatile fat acids in one gram fat.		
May 31..	17.23	3.33	3.41	8.95	.672	.....	.....	3.48	Before injection.	
June 1..	14.60	3.57	2.80	6.13	.663	.....	.....	4.85	Do.	
5..	17.77	2.77	2.88	10.25	.620	.084	.094	4.00	After injection.	

NO. 286.

May 31..	10.41	4.16	0.74	2.29	.625	.....	.....	9.34	Before injection.	
June 1..	10.17	5.00	1.02	2.55	.610	.....	.....	11.68	Do.	
5..	10.44	4.16	1.04	2.55	.556	.124	.138	12.15	After injection.	

NO. 217.

May 31..	12.03	4.16	2.82	2.43	.711	.....	.....	10.04	Before injection.	
June 1..	10.25	4.16	2.29	1.27	.606	.....	.....	15.74	Do.	
5..	11.26	4.16	2.70	2.03	.688	.176	.196	16.45	After injection.	

NO. 290.

May 31..	15.57	3.33	3.26	7.66	.622	.....	.....	5.09	Before injection.	
June 1..	14.96	3.85	2.70	7.17	.707	.....	.....	4.99	Do.	
5..	15.87	3.33	3.31	8.19	.549	.097	.108	5.93	After injection.	

TABLE V.—Temperature reaction of cows on repeated injections with tuberculin.

Fourth injection, tuberculous cows Nos. —				Fifth injection, tuberculous cows Nos. —				Third injection—	
Date.	Time.	285.	286.	Date.	Time.	285.	286.	Tuberculous cow No. 290.	Healthy cow No. 217.
Temperature.				Temperature.				Temperature.	
May 16..	7 a. m.	100.4	99.6	May 31..	6 a. m.	100.7	100.2	101.0	100.2
	9 a. m.	99.4	100.2		8 a. m.	100.2	100.0	100.5	100.0
	11 a. m.	100.8	100.6		10 a. m.	101.5	101.2	101.0	101.2
	1 p. m.	101.0	100.6		12 m.	101.2	100.2	101.0	100.8
	3 p. m.	100.0	101.0		2 p. m.	101.2	101.8	101.5	101.4
	5 p. m.	101.4	101.5		4 p. m.	101.2	101.0	100.4	100.7
	7 p. m.	101.0	101.4		6 p. m.	101.7	101.6	102.0	102.0
	10 p. m.	101.0	101.0		8 p. m.	101.8	102.6	102.4	102.2
Injected 2cc. tuberculin at 10:15 p. m.				Injected 2 cc. tuberculin.					
May 17..	7 a. m.	100.8	100.2	June 1..	6 a. m.	101.5	100.4	102.6	100.7
	9 a. m.	101.0	100.6		8 a. m.	101.2	100.5	103.0	101.5
	11 a. m.	101.4	100.8		10 a. m.	102.4	102.4	105.0	101.4
	1 p. m.	101.7	101.0		12 m.	103.2	102.0	105.6	101.8
	3 p. m.	101.0	101.6		2 p. m.	103.4	102.4	105.6	101.0
	5 p. m.	101.2	102.2		4 p. m.	103.7	102.8	105.0	102.2
	7 p. m.	101.8	103.5		6 p. m.	102.5	103.2	104.0	101.7
	9 p. m.	101.8	102.6		8 p. m.	101.8	102.4	103.2	101.8

TABLE V.—*Temperature reaction of cows on repeated injections with tuberculin—Cont'd.*

Date.	Time.	Sixth injection, tuberculous cows Nos. —		Calf of 284.*
		285.	286.	
		Temperature.		Tempera- ture.
July 5.....	7 a. m.	101.0	100.5	.....
	9 a. m.	101.6	100.7	102.0
	11 a. m.	102.8	103.2	101.6
	1 p. m.	102.6	102.2	102.4
	3 p. m.	103.0	102.7	102.8
	5 p. m.	102.8	102.4	103.2
	7 p. m.	103.2	103.8	102.6
	9 p. m.	102.0	102.7	103.8
		Injected at 9 p. m.	Tuberculin.	
		2 cc.		3 cc.
July 6.....	7 a. m.	101.4	100.8	101.6
	9 a. m.	101.4	100.6	101.2
	11 a. m.	103.0	103.0	101.8
	1 p. m.	102.6	101.6	102.0
	3 p. m.	103.0	102.6	102.8
	5 p. m.	101.5	101.8	103.0
	7 p. m.	101.7	101.6	103.4

* Two months old.

TABLE VI.—*Normal daily percentage variations in the constituents of milk from diseased and healthy cows.*

NO. 285.

Date.	Total solids.	Sugar.	Albumi- noids.	Fat.	Ash (milk).	Iodine number.	No. cc. 10 Ba (OH) ₂ req. for vol- atile fat acids in one gram fat.	Acidity (lactic) acid.	No. cc. 10 NH ₄ OH required for 1 cc. milk.
June 11.	16.24	3.12	4.15	8.71	.403	36.07	3.40	.063	.07
12.	14.47	3.12	4.16	6.14	.530	.....	3.74	.070	.07
13.	14.25	3.12	3.94	6.65	.478	34.43	4.06	.068	.08
14.	14.53	3.12	4.13	7.67	.638	30.68	4.34	.065	.07
15.	14.34	3.12	3.99	6.65	.662	33.74	4.65	.062	.07

NO. 217.

June 11.	11.97	4.16	4.17	2.03	.590	28.97	12.52	.149	.17
12.	10.82	4.16	3.83	1.52	.602	21.17	15.00	.158	.18
13.	11.30	4.16	3.97	2.02	.751	29.10	14.35	.100	.18
15.	11.62	4.16	4.25	2.03	.767	27.76	18.07	.100	.18

NO. 280.

June 11.	16.35	3.12	4.26	8.19	.596	30.51	5.25	.094	.106
12.	15.13	3.84	3.95	6.64	.620	28.79	5.51	.118	.114
13.	15.71	3.33	4.03	7.15	.592	28.85	7.84	.119	.134
14.	15.31	3.57	4.01	7.14	.625	.....	6.80	.114	.130
15.	16.22	3.84	4.25	7.66	.641	27.14	6.64	.115	.130

TABLE VII.—*Temperature records of station herd taken previous to first inoculation with tuberculin.*
 [Wisconsin Experiment Station herd, by Dr. Russell.]

No.	Name.	4 a. m.	6 a. m.	8 a. m.	12 m.	4 p. m.	8 p. m.	Average normal temperature.	Date of inoculation.	Kind of tuberculin.	Weight of animal.
1	Polly			101.3	101.8	101.6	101.0	101.42	Feb. 20, 10 p. m.	R. A. I.	779
4	Gay			101.0	100.9	101.3	101.0	101.50	do	R. A. I.	771
9	Daisy			99.6	101.2	101.4	101.2	100.85	do	R. A. I.	774
2	Bessie	101.8		101.6	101.4	102.0		101.70	do	R. A. I.	862
3	Doubtful	101.5		101.6	101.4	101.2		101.42	Feb. 23, 5 p. m.	R. A. I.	862
5	Angie	101.1		101.7	101.0	101.3		101.28	do	R. A. I.	1,077
6	Galena	101.2		101.2	100.4	101.0		101.20	do	R. A. I.	979
15	Melvina	101.8		102.1	102.0	102.0		101.97	do	R. A. I.	1,280
16	Miss Cowlip (sixth)	101.0		101.8	99.4	101.6		101.30	do	R. A. I.	1,317
7	Rue	103.3	101.4		99.4	100.0		101.25	do	R. A. I.	980
8	Neth Nugget	100.2	100.6		100.4	101.7		100.73	March 13, 4 p. m.	R. A. I.	1,122
10	Bunn	102.5	102.2		101.8	102.0		102.08	do	R. A. I.	1,280
11	Beauty	101.1	101.2		99.6	101.6		100.88	do	R. A. I.	1,120
12	Bessie (second)	102.0	102.0		100.4	101.8		101.55	do	R. A. I.	800
13	Palmyra	101.2	101.7		100.6	101.6		101.28	do	R. A. I.	804
14	Penny	102.3	102.0		101.6	101.9		101.62	do	R. A. I.	816
18	Colantha Rose	102.1	102.1		102.0	102.1		102.04	do	R. A. I.	823
19	Experimentalist	101.1	101.5		101.0	102.0		101.40	do	R. A. I.	1,328

TABLE VII—Continued.
Temperature records of station herd subsequent to first inoculation with tuberculin.
 Hours after injection.

No.	Name.	Average normal temperature.	6 hours.	8 hours.	9 hours.	10 hours.	11 hours.	12 hours.	14 hours.	16 hours.	18 hours.	20 hours.	24 hours.	28 hours.	40 hours.	Reaction above average normal.	Reaction above highest normal.
1	Polly	101.42	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	4.8	4.6
4	Gay	101.05	.....	.....	103.9	.....	104.9	106.0	106.2	103.4	105.0	105.0	.....	.....	.....	3.4	3.1
4	Daisy	100.85	.....	.....	101.7	.....	102.7	103.9	104.4	104.0	102.5	101.5	.....	.....	.....	3.0	2.4
2	Beaclin	101.70	.....	.....	102.4	.....	.....	103.8	100.6	102.4	102.4	101.5	.....	.....	.....	1.6	1.3
2	Doubtful	101.42	.....	.....	.....	.....	102.7	103.3	103.2	103.3	102.6	102.4	.....	.....	.....	1.7	1.5
5	Aggie	101.28	.....	.....	.....	.....	.....	101.9	102.3	103.1	102.4	101.6	.....	.....	.....	4.3	3.0
6	Galea	101.20	.....	.....	.....	.....	.....	105.2	105.6	104.9	103.8	102.3	.....	.....	.....	3.7	2.7
15	Melvin	101.07	.....	.....	.....	.....	.....	103.4	104.2	104.9	103.7	102.5	.....	.....	.....	4.4	4.3
16	Miss Cowslip	101.30	.....	.....	.....	.....	.....	106.4	105.6	106.4	105.0	105.1	.....	.....	.....	1.2	0.9
7	Rue	101.25	.....	.....	.....	.....	.....	102.2	102.5	102.5	101.8	101.9	.....	.....	.....	1.6	1.4
8	Nugget	100.73	.....	.....	.....	.....	.....	102.8	101.2	.....	101.6	98.7	102.0	.....	.....	2.8	1.8
10	Bunn	102.08	.....	.....	.....	.....	.....	102.1	102.4	.....	103.5	101.8	102.4	.....	.....	0.6	0.4
11	Beatty	100.88	.....	.....	.....	.....	.....	101.6	101.5	.....	102.7	102.1	102.7	.....	.....	1.6	0.9
12	Beattie (second)	101.55	.....	.....	.....	.....	.....	101.3	101.6	.....	102.5	101.0	101.9	.....	.....	3.1	2.4
13	Palmyra	101.28	.....	.....	.....	.....	.....	102.1	102.1	.....	104.6	103.2	102.5	.....	.....	3.6	3.2
14	Finny	101.95	.....	.....	.....	.....	.....	102.3	103.2	.....	104.9	102.4	102.2	.....	.....	2.0	1.7
18	Colantha Rosa	101.86	.....	.....	.....	.....	.....	102.0	102.5	.....	106.5	105.0	103.1	.....	.....	4.6	4.4
19	Experimentalist	101.40	.....	.....	.....	.....	.....	103.3	104.0	.....	105.7	106.5	103.3	103.2	103.7	5.1	4.5
								102.4	102.3			106.5	105.2	104.2	104.8		

TABLE VIII.—*Temperature records of herd preliminary to second inoculation.*
 Wisconsin Experiment Station herd, by Dr. Russell.

No.	Name.	4 p. m.	6 a. m.	12 m.	3 p. m.	Average normal temperature.	Date of inoculation.	Kind of tuberculin.	Weight of animal.
1	Polly	102.2	102.2	100.6	101.8	101.70	March 30, 4 p. m.	Koch	Pounds, 770
4	Gay	101.2	101.6	99.7	101.4	100.00	do.	Koch	845
6	Daisy	101.1	102.2	99.9	101.7	101.22	do.	Koch	866
9	Beasen	101.1	101.8	101.8	101.1	101.45	May 3, 4 p. m.	Koch	814
2	Doubtful	101.7	101.4	102.0	101.5	101.65	do.	Koch	833
5	Aggie	101.4	101.6	102.7	101.1	101.45	do.	Koch	816
6	Galena	102.2	101.9	101.8	99.7	101.38	do.	Koch	811
15	Melvin	102.1	101.1	101.1	101.2	101.12	do.	Koch	1,240
7	Cowslip	102.1	101.9	103.2	101.4	102.12	do.	Koch	1,236
8	Rae	100.5	101.5	101.8	100.3	101.92	do.	B. A. I.	889
10	Nugget	101.3	101.3	101.8	101.8	101.62	do.	B. A. I.	944
11	Bunn	101.3	101.3	101.8	101.8	101.20	do.	B. A. I.	1,131
11	Beauty	101.6	101.5	101.8	101.8	101.40	do.	B. A. I.	852
13	Palmira	101.7	101.4	102.0	101.7	101.48	do.	B. A. I.	821
13	Pussy	101.7	101.4	102.0	101.8	101.50	do.	B. A. I.	780
13	Beals (second)	101.3	99.4	100.3	100.8	100.30	do.	B. A. I.	694
18	Calantha Rosa	101.9	101.4	101.9	101.2	101.60	do.	B. A. I.	866
19	Experimentalist	102.0	101.2	102.0	102.0	101.80	do.	B. A. I.	1,261

TABLE VIII—Continued.
Temperature after inoculation.
 Hours after inoculation.

No.	Name.	Average normal	5 hours.	8 hours.	10 hours.	13 hours.	16 hours.	18 hours.	20 hours.	24 hours.	Reaction above average normal.	Reaction above highest normal.	Autopsy.
1	Polly.....	101.70	103.7	104.5	104.9	105.1	103.4	102.7	102.6	.....	3.4	2.8	Tuberculous.
4	Gay.....	101.00	101.3	101.2	101.1	101.5	101.7	101.5	101.1	.....	0.7	0.1	Do.
9	Daisy.....	101.92	101.5	101.2	101.1	101.7	101.8	102.0	102.3	99.7	1.1	0.1	Do.
2	Beacoin.....	101.42	101.5	101.5	101.2	101.4	102.0	102.9	101.5	.....	1.4	1.1	Not killed.
3	Doubtful.....	101.65	101.4	101.2	101.8	102.5	102.2	102.1	102.0	.....	0.8	0.5	Do.
5	Aargio.....	101.45	102.5	102.0	101.8	102.0	102.2	102.4	102.9	102.7	1.5	0.2	Tuberculous.
6	Galena.....	101.33	101.7	101.7	101.6	101.7	102.2	101.8	101.6	.....	0.8	0.0	Do.
15	Melvina.....	101.12	101.5	101.8	101.9	102.4	101.9	102.2	103.1	103.0	2.0	1.9	Do.
16	Cowslip.....	102.12	102.5	101.8	102.4	102.1	103.6	103.4	103.4	.....	1.4	0.2	Not killed.
7	Rue.....	100.98	101.0	101.0	101.4	103.1	104.0	104.5	104.4	.....	3.5	3.0	Tuberculous.
8	Neth Nugget.....	101.98	101.5	101.8	102.2	103.3	105.2	104.9	104.7	.....	3.5	3.4	Do.
10	Burn.....	101.50	100.9	101.3	101.5	103.4	103.3	102.6	102.4	.....	2.1	2.1	Do.
11	Beauty.....	101.60	101.6	101.4	101.8	102.6	102.9	102.7	102.5	.....	1.3	1.1	Do.
13	Palmyra.....	101.43	101.3	101.5	101.9	104.6	105.4	105.5	105.1	.....	4.0	3.8	Do.
14	Pansy.....	101.50	102.0	103.0	103.9	105.0	104.9	104.6	104.2	.....	3.4	3.0	Do.
12	Bees (second).....	100.50	104.1	103.6	103.0	102.6	102.0	101.8	101.9	.....	3.8	2.8	Do.
13	Colantha Rose.....	101.60	101.8	102.1	101.8	102.6	103.1	102.7	102.1	.....	1.4	1.1	Do.
19	Experimentalist.....	101.80	102.4	105.0	105.7	105.6	103.9	104.9	105.4	103.8	3.9	3.7	Do.

TABLE IX.—*Reaction in temperature with tuberculin in tuberculous guinea pigs at different dates after infection.*

No. 429.				No. 426.			No. 426 II.		
	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.
Before injection.	July 20	10 a. m.	102.6	July 21	10 a. m.	103.4	July 22	9 a. m.	102.4
	Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.		
After injection	July 20	12 m.	102.8	July 21	12 m.	104.4	July 22	11 a. m.	103.2
	July 20	2 p. m.	103.6	July 21	2 p. m.	104.4	July 22	1 p. m.	104.0
	July 20	4 p. m.	103.0	July 21	4 p. m.	103.4	July 22	3 p. m.	103.2
No. 424.				No. 424 II.			No. 429 II.		
	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.
Before injection.	July 24	10 a. m.	103.2	July 25	10 a. m.	103.4	July 26	10 a. m.	102.8
	Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.		
After injection	July 24	12 m.	104.2	July 25	12 m.	103.2	July 26	12 m.	104.6
	July 24	2 p. m.	104.4	July 25	2 p. m.	103.8	July 26	2 p. m.	103.8
	July 24	4 p. m.	103.6	July 25	4 p. m.	103.2	July 26	4 p. m.	103.4
No. 429 III.				No. 424 III.			No. 426 IV.		
	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.
Before injection.	July 27	10 a. m.	102.4	July 28	10 a. m.	103.2	July 29	10 a. m.	102.6
	Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.		
After injection	July 27	12 m.	103.8	July 28	12 m.	104.0	July 29	12 m.	103.8
	July 27	2 p. m.	103.0	July 28	2 p. m.	103.8	July 29	2 p. m.	104.0
	July 27	4 p. m.	103.4	July 28	4 p. m.	103.6			
No. 430.				No. 430 II.			No. 425.		
	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.
Before injection.	July 20	10 a. m.	103.0	July 21	10 a. m.	102.6	July 22	9 a. m.	103.6
	Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.		
After injection	July 20	12 m.	102.8	July 21	12 m.	103.6	July 22	11 a. m.	103.8
	July 20	2 p. m.	103.6	July 21	2 p. m.	103.6	July 22	1 p. m.	104.2
	July 20	4 p. m.	103.6	July 21	4 p. m.	103.4	July 22	3 p. m.	104.0
No. 425 II.				No. 421.			No. 421 II.		
	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.
Before injection.	July 24	10 a. m.	102.0	July 25	10 a. m.	102.6	July 26	10 a. m.	102.8
	Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.		
After injection	July 24	12 m.	103.6	July 25	12 m.	103.4	July 26	12 m.	104.6
	July 24	2 p. m.	104.0	July 25	2 p. m.	103.6	July 26	2 p. m.	103.6
	July 24	4 p. m.	104.0	July 25	4 p. m.	103.4	July 26	4 p. m.	103.6

TABLE IX.—*Reaction in temperature with tuberculin in tuberculous guinea-pigs at different dates after infection—Continued.*

No. 430 III.				No. 430 IV.			No. 425 III.		
	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.
Before injection.	July 27	10 a.m.	102.6	July 28	10 a.m.	103.0	July 29	10 a.m.	103.6
	Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.		
After injection {	July 27	12 m.	104.2	July 28	12 m.	104.2	July 29	12 m.	104.0
	July 27	2 p.m.	103.4	July 28	2 p.m.	104.3	July 29	2 p.m.	104.6
	July 27	4 p.m.	103.6	July 28	4 p.m.	104.0			
No. 428.				No. 435.			No. 433.		
	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.
Checks. { Before injection	July 20	10 a.m.	104.0	July 21	10 a.m.	102.4	July 22	9 a.m.	102.2
	Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.		
	July 20	12 m.	103.4	July 21	12 m.	102.6	July 22	11 a.m.	101.2
After injection {	July 20	2 p.m.	103.4	July 21	2 p.m.	102.6	July 22	1 p.m.	101.8
	July 20	4 p.m.	102.6	July 21	4 p.m.	102.6	July 22	3 p.m.	102.4
No. 432.				No. 431.			No. 435 II.		
	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.
Checks. { Before injection	July 24	10 a.m.	101.2	July 25	10 a.m.	101.6	July 26	10 a.m.	102.6
	Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.		
	July 24	12 m.	100.6	July 25	12 m.	102.0	July 26	12 m.	103.6
After injection {	July 24	2 p.m.	101.6	July 25	2 p.m.	102.8	July 26	2 p.m.	103.0
	July 24	4 p.m.	102.4	July 25	4 p.m.	103.0	July 26	4 p.m.	102.8
No. 436.				No. 427.			No. 428.		
	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.
Checks. { Before injection	July 27	10 a.m.	102.6	July 28	10 a.m.	101.8	July 29	10 a.m.	102.8
	Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.		
	July 27	12 m.	102.4	July 28	12 m.	102.6	July 29	12 m.	103.2
After injection {	July 27	2 p.m.	103.0	July 28	2 p.m.	102.2	July 29	2 p.m.	104.0
	July 27	4 p.m.	103.0	July 28	4 p.m.	102.0			

TABLE X.—*Reaction in temperature with tuberculin in tuberculous guinea pigs at different dates after infection.*

	No. 482.			No. 482.			No. 486.		
	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.
Before injection.	Oct. 12	10 a. m.	101.8	Oct. 16	9:30 a. m.	102.6	Oct. 18	9:30 a. m.	102.2
	Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.		
After injection.	Oct. 12	1:15 p. m.	102.8	Oct. 16	11:30 a. m.	102.4	Oct. 18	11:30 a. m.	102.4
	Oct. 12	3:45 p. m.	103.0	Oct. 16	3 p. m.	102.2	Oct. 18	3:30 p. m.	101.6
							Oct. 18	6 p. m.	102.4
	No. 482.			No. 486.			(Inoculated July 10, 1893.) No. 428.		
	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.
Before injection.	Oct. 25	9:30 a. m.	102.0	Nov. 1	9:30 a. m.	102.2	Nov. 8	10 a. m.	103.0
	Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.		
After injection.	Oct. 25	12 m.	102.8	Nov. 1	12 m.	102.2	Nov. 8	12 m.	105.0
	Oct. 25	2 p. m.	102.6	Nov. 1	2 p. m.	102.6	Nov. 8	2 p. m.	106.2
	Oct. 25	4 p. m.	102.4	Nov. 1	4 p. m.	103.2	Nov. 8	4 p. m.	105.0
	Oct. 25	6:15 p. m.	102.2	Nov. 1	6 p. m.	102.4			
	No. 487 (a).			No. 487 (a).			No. 484 (d).		
	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.
Checks. Before injection	Oct. 12	10 a. m.	103.0	Oct. 16	9:30 a. m.	103.4	Oct. 18	9:30 a. m.	102.4
	Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.		
After injection	Oct. 12	1:15 p. m.	104.0	Oct. 16	11:30 a. m.	103.4	Oct. 18	11:30 a. m.	104.0
	Oct. 12	3:45 p. m.	103.8	Oct. 16	3 p. m.	103.0	Oct. 18	3:30 p. m.	103.0
				Oct. 16	6 p. m.	102.4	Oct. 18	6 p. m.	102.8
	No. 487 (a).			No. 484 (d).			(Inoculated July 10, 1893.) No. 425.		
	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.	Date.	Time.	Tem- pera- ture.
Checks. Before injection	Oct. 25	9:30 a. m.	103.2	Nov. 1	9:30 a. m.	101.8	Nov. 8	10 a. m.	103.4
	Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.		
After injection	Oct. 25	12 m.	103.2	Nov. 1	9:30 a. m.	102.2	Nov. 8	12 m.	104.2
	Oct. 25	2 p. m.	103.0	Nov. 1	2 p. m.	102.6	Nov. 8	2 p. m.	106.4
	Oct. 25	4 p. m.	103.0	Nov. 1	4 p. m.	102.6	Nov. 8	4 p. m.	105.8
	Oct. 25	6:15 p. m.	102.8	Nov. 1	6 p. m.	102.4			

TABLE X.—*Reaction in temperature with tuberculin in tuberculous guinea pigs at different dates after infection*—Continued.

	No. 483.			No. 485.			No. 483.		
	Date.	Time.	Temperature.	Date.	Time.	Temperature.	Date.	Time.	Temperature.
Before injection	Oct. 14	9:30 a.m.	102.8	Oct. 16	9:30 a.m.	102.4	Oct. 18	9:30 a.m.	103
After injection	Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.		
	Oct. 14	11:30 a.m.	103.8	Oct. 16	11:30 a.m.	102.0	Oct. 18	11:30 a.m.	104.0
	Oct. 14	2:30 p.m.	103.8	Oct. 16	3 p.m.	102.8	Oct. 18	3:30 p.m.	103.4
	Oct. 14	6:15 p.m.	103.8	Oct. 16	6 p.m.	102.6	Oct. 18	6 p.m.	103.4
	No. 485.			No. 483.			(Inoculated Oct. 7, 1893.) No. 485.		
	Date.	Time.	Temperature.	Date.	Time.	Temperature.	Date.	Time.	Temperature.
Before injection	Oct. 25	9:30 a.m.	102.6	Nov. 1	9:30 a.m.	102.4	Nov. 8	10 a.m.	102.0
After injection	Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.		
	Oct. 25	12 m.	103.4	Nov. 1	12 m.	102.6	Nov. 8	12 m.	103.6
	Oct. 25	2 p.m.	103.2	Nov. 1	2 p.m.	102.6	Nov. 8	2 p.m.	104.0
	Oct. 25	4 p.m.	103.0	Nov. 1	4 p.m.	103.4	Nov. 8	4 p.m.	103.0
	Oct. 25	6:15 p.m.	103.0	Nov. 1	6 p.m.	103.0			
	No. 486 (b).			No. 481 (c).			No. 488 (b).		
	Date.	Time.	Temperature.	Date.	Time.	Temperature.	Date.	Time.	Temperature.
Before injection	Oct. 14	9:30 a.m.	102.2	Oct. 16	9:30 a.m.	103.0	Oct. 18	9:30 a.m.	102.0
After injection	Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.		
	Oct. 14	11:30 a.m.	101.8	Oct. 16	11:30 a.m.	102.6	Oct. 18	11:30 a.m.	102.6
	Oct. 14	2:30 p.m.	102.8	Oct. 16	3 p.m.	102.8	Oct. 18	3:30 p.m.	101.6
	Oct. 14	6:15 p.m.	102.8	Oct. 16	6 p.m.	102.8	Oct. 18	6 p.m.	102.8
	No. 481 (c).			No. 488 (b).			(Inoculated Oct. 7, 1893.) No. 481 (c).		
	Date.	Time.	Temperature.	Date.	Time.	Temperature.	Date.	Time.	Temperature.
Before injection	Oct. 25	9:30 a.m.	103.0	Nov. 1	9:30 a.m.	102.0	Nov. 8	10 a.m.	101.6
After injection	Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.			Injected $\frac{1}{2}$ cc. tuberculin.		
	Oct. 25	12 m.	103.0	Nov. 1	12 m.	101.6	Nov. 8	12 m.	103.6
	Oct. 25	2 p.m.	102.8	Nov. 1	2 p.m.	102.0	Nov. 8	2 p.m.	103.8
	Oct. 25	4 p.m.	102.6	Nov. 1	4 p.m.	102.2	Nov. 8	4 p.m.	103.6
	Oct. 25	6:15 p.m.	102.6	Nov. 1	6 p.m.	102.2			



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